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CONTENTS.

DISCUSSION OF PRIZE ESSAY, 1887. THE NAVAL BRIGADE: ITS ORGANIZATION, EQUIPMENT, AND TACTICS, ... 511

Annapolis, Md. Lieutenant D. H. MAHAN, 511.—Lieutenant COLAHAN, 518.—Lieutenant-Commander HUTCHINS, 518.

Newport Branch. Commander BAINBRIDGE-HOFF, 521.—Lieutenant A. C. DILLINGHAM, 522.—Lieutenant CLASON, 528.—Major W. R. LIVERMORE, 529.—Commander C. F. GOODRICH, 530.—Commander BAINBRIDGE-HOFF, 531.—Lieutenant-Commander C. T. HUTCHINS, 532.—Rear-Admiral S. B. LUCE, 536.

Washington Branch. Ensign W. L. RODGERS, 537.—Lieutenant C. G. CALKINS, 538.—Lieutenant-Commander STOCKTON, 541.—Lieutenant RUSH, 542.—Commander A. D. BROWN, 544.

INFANTRY-FIRE TACTICS, FIRE DISCIPLINE, AND MUSKETRY INSTRUCTION, AND PRACTICE WITH RAPID-FIRING CANNON. By Lieutenant-Commander C. T. Hutchins, U. S. N., ... 547

THE V GUN SHIELD FOR CRUISERS. By Chief Engineer N. B. Clark, U. S. N., ... 561

THE SEPARATION OF THE PASSAGE AND EMERGENCY POWERS FOR WARSHIPS. By Chief Engineer N. B. Clark, U. S. N., ... 565

NOTES ON THE LITERATURE OF EXPLOSIVES. XV. By Professor Charles E. Munroe, ... 567

ALUMINUM BRONZE FOR HEAVY GUNS. By Alfred H. Cowles. With Discussion, ... 601

A Résumé of the History of Aluminium. By JOSEPH W. RICHARDS, M. A., A. C., 612.—EUGENE H. COWLES, 615.—BEN. M. PLUMB, 616.—WM. METCALF, 616.—Professor R. H. THURSTON, 617.—Lieutenant M. E. HALL, U. S. N., 620.—EDWARD W. VERY, 622.—Lieutenant ALBERT GLEAVES, 629.—Ensign J. H. GLENNON, 632.—BIRDSILL HOLLY, 634.—THOMAS D. WEST, 638.—Professor CHAS. F. MABERY, 640.—Dr. R. J. GATLING, 641.—ROMAINE C. COLE, 642.—WM. H. BROWN, 645.—P. A. Engineer G. W. BAIRD, 646.—J. R. HASKELL, 647.—ALFRED H. COWLES, 654.—Lieutenant AUSTIN M. KNIGHT, 655.—EUGENE H. COWLES, 657.—R. Van LANGHENHOVE, University of Liège, Belgium, 663.—T. C. MENDENHALL, 671.

PROFESSIONAL NOTES, ... 673

BOOK NOTICES, ... 695

BIBLIOGRAPHIC NOTES, ... 697

OFFICERS OF THE INSTITUTE AND BRANCHES FOR 1888, ... 711

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DISCUSSION OF PRIZE ESSAY, 1887.

THE NAVAL BRIGADE: ITS ORGANIZATION, EQUIPMENT, AND TACTICS.

By LIEUTENANT C. T. HUTCHINS, U. S. Navy.

ANNAPOLIS, MD.,

OCTOBER 14, 1887.

Commander W. T. SAMPSON, U. S. N., Vice-President, in the Chair.

Lieutenant D. H. MAHAN.—*Mr. Chairman and Gentlemen:*—By quoting the essayist's words, "There should be no sparing of criticism until we have attained uniformity in the combination of the guns' crews and the battalions of a fleet of vessels meeting even for the first time," I will make my text.

Criticism, when friendly, is but the statement of a difference of opinion. While agreeing with the essayist in the greater part of his article, I am forced to differ from him in some particulars; and to these I will call your attention by mentioning the pages. For instance, on p. 306, I think there should be no difference in the numbering or designation of companies in battalions, as all, marines as well as sailors, belong to the one organization, and should come under the same rules and same numberings. Otherwise, the orders in the tactical books should be changed and orders such as this be substituted: "1st companies and company A, deploy as skirmishers."

Again, on p. 307: "Any division . . . . . should not be thought of." It becomes absolutely necessary, at times, to break up companies, and provision

should be made to that end—the unexpected should be most carefully provided for. On the same page—his numbers for the company should be increased; instead of guides there should be signal men, each company to have two allowed to it when on detached duty. The file closers should be four, besides the 1st and 2d sergeants, to allow for guard duty. The ammunition passers, *if necessary*, should be separate from the company, and all passers should be incorporated in one body under its proper officers, and passers should be detailed to each battalion as circumstances may suggest. Suppose that the passers of a company should be killed just at the critical moment, the ammunition having given out, the company would be unable to get further supplies, and would either have to retreat from an important position or submit to capture. I do not consider passers very important, and I prefer, before going into action, to fill up all the men's pockets, for, as General Von Kraft says: "When a line of skirmishers advancing to attack across an open plain has arrived within one hundred or two hundred paces of the enemy, and finds itself short of cartridges, no fresh supply can be obtained. No wagons, not even a man can reach the fighters, and should for a wonder fortune favor some brave fellow in doing so, of what use would his 500 rounds be to the company?" And again, in a lecture before the Royal United Service Institution, Captain Walter H. James says: "How are you to carry the increased number of rounds the soldier must have? He cannot carry beyond a certain weight, and that weight must in the future consist very largely of cartridges. Is it possible under modern fire to send cartridges to the fighting line? I doubt it; far better at the last moment before entering an action serve out an additional supply, fairly sufficient for the fight, and only send more to the firing line as an exceptional circumstance." The company should consist of from 48 to 54 privates with six sergeants. The signal men referred to should form a body to be used as orderlies for headquarters and battalion commanders and to be sent with any detached body.

On p. 308—"On drill days, two markers, etc." Do not have anything during a drill that you would not have in actual service; consider what General Wolseley says: "I consider it a very dangerous thing to teach a soldier in peace anything which he is not likely to practise in war." So why teach him to rely on a marker for distance, or on a drummer for the cadence of step? An illustration may be drawn from the last flag drill—while the cadets marched very well to music, when the music was silent they very soon began to bob up and down as if dancing the polka.

On p. 309—The artillery company is very much too small; sixteen men for the piece and seven additional for the limber would make but sorry work on a march. In the Egyptian campaign, a crew for a Gatling gun was composed of 30 men, and in addition thereto four mules; sometimes all of these found it difficult to move the piece. I do not think that a piece of artillery with a limber should be manned by less than a company of infantry for general work. In a lecture delivered by Major A. D. Anderson, R. H. A., before the Royal United Service Institution, he proposes to give the machine guns to the infantry, in the proportion of one gun to a company. He, however, does not carry his gun as we would, but proposes to carry the gun and tripod on one mule and the

ammunition on another. He says: "We thus ensure all the companies in the regiment taking an interest in their own gun and training men for work with it." By giving a company as the allowance per gun there would be a sufficient number for a heavy drag, and the men not stationed on the drag rope would be valuable as an infantry reserve in action, or as guards on the march.

Referring to (p. 304) the attempt to organize the ship's company with the battalion as a basis, and again, on p. 310, as to regulations of Ordnance Manual, I would suggest that companies should first be formed and then apportioned to a ship as may be necessary to fill the ship's fighting quota; there may be a few extra men, but better so than too few. To support my position I will quote some words of General Von Kraft, to whom the essayist refers on p. 329. "My desire is that elementary tactical instruction should be completed in the company instead of being carried on, as now, in the battalion. Hence the company has become the real tactical unit." And again, from General Sir Lumley Graham's work: "The importance of the company as a battle unit is much increased, and *pari passu* the importance of the captain as a commander."

Neither the powder nor the engineer's divisions should be landed. They are now the two most necessary divisions on board ship, and in the event of a landing in an enemy's country, they are the ones who should be left to protect the ship. For this purpose the engineer's division should be thoroughly drilled in the management of all guns, and then, in case of attack during the absence of the brigade, the men on watch could manage the engines, while the men off watch handled the guns with the assistance of the powder division. The handling of charges and projectiles will be the turning point in an engagement, and for that reason the powder division should not be interfered with in the slightest degree, lest its efficiency should be impaired.

On p. 311—I wish the essayist had specified a little more clearly from what ships the twenty companies and the ten pieces of artillery are to be drawn. It is easy to say, land so many men, but the thing is to detail them to the different ships according to their rates. With such a detail made out an admiral or commander of a fleet could tell at a glance just how many men he could land; that is, how many companies and pieces of artillery. There should be a fixed and unalterable plan. At the present time too much is left to the executive officer, and that accounts for the "very dissimilar battalion organizations." Should such a plan be adopted, an executive officer would be spared much trouble, and would have more time to devote to his present onerous duties.

From the same page it would appear that two medical officers are enough for the brigade. I think that there should be one surgeon to every battalion of three companies, besides the surgeon on the staff—remembering that there must be some detached work. The allowance of two surgeons to 1295 men (not counting the officers) is clearly insufficient.

As to the pioneers (p. 311), it must be allowed that they will have plenty to do without helping the ammunition passers. The pioneers should correspond to the army engineers, and should be drilled in such work as generally falls to the lot of the army engineer.

On p. 312 it is suggested that the marines should be landed in boats pulled by sailors. The objection to this would be the number of sailors required to pull a certain number of marines ashore; if the marines cannot pull themselves (as they should), send them ashore in steam launches. As to the Intelligence Staff (p. 312), I think it would be desirable to have the officers from the Office of Intelligence on the immediate staff of the commander of the brigade. It is to be supposed that, being sent from that office, they will be well acquainted with the country in which they are to serve, and on that account should be continually near the commanding officer. On p. 313 is mentioned one signal officer; he should be in charge of all signal men, and besides being headquarters signal officer he should be an aide to the brigade commander.

In regard to the equipment of the sailor (p. 315)—for a firearm the Lee magazine gun is to be preferred. With it the sailor is not given the opportunity to use the magazine nearly as much as with a rifle which carries its magazine in the stock. The magazines for the Lee are easily carried in the waist belt, and by one simple movement a man, if hard pressed, is given command of five shots. With a stock-magazine rifle he will, in nine cases out of ten, have emptied the magazine in his hurried advance to the fire line, and at the moment of his greatest danger he will have an empty magazine and have to resort to loading by hand. Only by continued fire-practice can the critical moment be so guarded against that the men may always be provided with ammunition. This must be brought about, as Prince Hohenlohe says, "by repeating the simple routine"—the context shows that he means a real action exercise—"hundreds and thousands of times."

I must differ from the essayist as to the arming of a gun's crew; they should *all* be armed with magazine rifles, preferably with the Lee. It will be necessary, at some stage of an action, to change the men serving the guns. Will they have time to change their belts and equipments so as to keep the men stationed at the guns uniformly armed? If they will not have time, why make any difference in the equipment of the crews?

On p. 315 the proviso is made, "should limbers be landed." There should be no limiting word, the instructions should read—limbers will always be landed with pieces; in fact, it should be made as hard for our landing party to drag the piece alone as it is for the army. What would a field-piece be worth without a limber?

The same objection obtains in regard to arming the limber's crew (p. 316) as in regard to the gun's crew. As to shields for artillery, if these shields can be made a part of a gun carriage, serving to support the ammunition boxes when on the march, have them by all means; but if they are to add extra weight to the already heavy gun, do not have them.

Again (p. 316) I must differ from the essayist in regard to cutting down the supply of ammunition for light marching order. Powder (or ammunition) is what you must depend upon when you reach the point towards which the march is directed. Light marching order is such as will admit of quick, forced marching. It will be necessary at a time of great danger and when it is supposed the fighting will be short, sharp, and decisive—at a time when the force

will be able to return very soon, and consequently at a time when you should carry plenty of ammunition and doff the knapsack and other unnecessary weights.

It is well said on the same page that the sword is useless; it is worse than useless, it is in the way. So also with the bayonet; it will be of no use to a naval brigade if opposed to a body of troops armed with magazine rifles—if such weight is to be carried it should be as an entrenching tool.

The idea of a man carrying a blanket encircling the body, over the left shoulder (p. 317), should be done away with. In the recent orders issued to the armies of France and Germany this way of carrying the blanket is relegated to obscurity. In hot weather a blanket carried in this way is almost insupportable—in any weather it is in the way. The knapsack and blanket should be carried on the back, not to project more than two inches above the line of the shoulder.

In his reference to tents, on the same page, I presume the writer merely refers to landing for drills. It seems rather strange to think of men landing in an enemy's country with capstan bars and boat spars with which to erect tents. Let us rather rig our hatches with a different style of canopy frame, and have all covers made in the form of a tent, provide plenty of extra covers, with pipe poles and wire or pipe ridge poles, and there will be plenty of tents, taking up but very little room, and rendering unnecessary any application to the army for tents, or the carrying ashore of spars and sails.

On the same page medical officers are allowed to wear swords. Why? So that they may trip over them when hurrying to assist some wounded man? And why take ashore a master-at-arms and a ship's corporal? They are efficient petty officers on board ship, but spare Jack the sight of them ashore. It is provided (p. 318) that each officer and man shall have a piece of painted canvas to sleep upon, and it is suggested that a tarpaulin makes an admirable bed; there is, however, no consideration of the weight of these things. Can any one picture to himself the struggle *two* men have with *one* tarpaulin when covering a hatch at fire quarters!

In regard to the mounting of some of the officers—be sure they know how to ride before you put them on horseback. It is not a pretty sight to see an officer riding up Broadway holding on to the pommel of the saddle to keep himself down in his seat. When the brigade is under fire is just the time for all officers entitled to be mounted to be in the saddle, so that the colonels may give attention to such parts of their command as need encouragement, and that the aides may be ready to carry messages to the different parts of the field.

Passing over the tables of light and heavy marching order, we find given on p. 321 the strength of the Naval Brigade. Not knowing into how many battalions the twenty companies are divided, I can say nothing as to numbers, officers, etc., so I will only refer again to the paucity of surgeons and signal men, and, as regards the artillery, to the insufficient number of men for the work required.

The pioneers are very much handicapped (p. 322) by having to carry 13 pounds (tools, and a bag of miscellaneous implements); besides, 30 pioneers for such an expedition are insufficient.

On the subject of rations (p. 324) allow me to say, that although the ration on board ship is excellent, it is not altogether what is wanted for a landing party. Articles should be put up in small packages, say of four inches cube, and so packed in boxes as to be ready at hand when it is necessary to land the brigade. These cubes can be distributed amongst the men, while for half barrels and quarter barrels other means of transportation have to be employed. An entire change in the ration for the brigade would be beneficial. While on the subject of rations, moreover, it would have been well to give some ideas as to means for cooking.

Under the heading of Tactics—the cry for an immediate change in tactics is good. General Morris says: "A general change of front as made by an army is so different from the methods perplexingly described and geometrically illustrated in text-books, that it presents a curious instance of the difference between theory and practice." General Wolseley says: "The days when men advanced in line as at the Alma and elsewhere, are dead and gone." If these two authorities speak truly, does it not show that new tactics are necessary? The tactics now used by our army and navy are behind the times; we trust too much to appearance and forget the reality that will be necessary. We teach the touch and lock step, while forgetting to teach the man how to look out for himself when alone. As the essayist says: "Instead of masses . . . . . loose order will have to be adopted." Is not this a complete change?

In the advance by rushes it must be remembered that the rushes are not of such a length as to heat the blood to any great extent, and for that matter a body of troops under fire frequently has its blood very much heated while standing still. In advancing on the enemy now-a-days, shelter is to be sought after, and that speed in taking advantage of offered shelter is necessary is seen when it is realized that the enemy is standing quietly behind an earthwork, and ready to concentrate the fire of several upon one while shelter is sought. Might not the conditions mentioned as existing at Tel-el-Kebir have been much changed had the English been attacking a civilized foe? When the lamented Upton submitted his tactics it was with the knowledge that they would need to be changed almost entirely in twenty years. Has not that time come now? I would substitute "trail" for "carry" (p. 325) at all movements from a halt and "order."

The brigade being in column of battalions (the writer has deemed it advisable to advance in two or more columns, which I take to mean columns of battalions), skirmishers should be deployed by deploying in succession the companies of one battalion (p. 327). The battalion chosen to deploy should be determined upon in the plan of attack. All the battalions will, however, eventually reach the firing or fighting line.

The Grand Tactics phrase (p. 329) emphasizes my remark, that the number of men allowed to the piece of artillery is too small. I think also that the elementary *tactics* ought to teach all that is needed to bring a battery into action, and that all movements given therein should be performed at a "double time" speed. If the cutlass and bayonet are done away with for these men, they should be provided with a short entrenching tool (shovel and

pick combined), such as is now in use in the German army. By the increase of the gun's crew the infantry support can be assured. Before leaving this subject I wish to say that I gather from this essay that the artillery is to be drilled only as artillery and the infantry only as infantry. If that is the idea I wish to disagree, as I think a company of infantry should constitute the crew of a piece, and be as well versed in the management of the piece as in the manipulation of its own rifle.

The embarkation of the brigade in boats well merits all that the essayist has said—he might have gone further and said that our present boats are not fit for a first class navy. Why have larger and smaller boats? Why, with the new ships, can we not have a new style of steam launch, pulling cutter, and light pulling life boat? Why cannot these boats be all alike in their classes, and have these classes of the best? To what does the essayjst refer when he speaks of heavy boats? Does he propose to keep the pulling launches in the service, to wear out a man's life before he has pulled one half mile? He can scarcely refer to any of our present cutters, for there are but few which will stand the continual fire of a 3-pounder B. L. rifle.

There is one point on which I do not think stress enough has been laid—that of getting the machine guns ashore dry and clean, and also trying to get the men ashore dry-shod. There is nothing that makes the feet sore more quickly than a pair of wet shoes filled with sand. Cannot our whale boats be so rigged as to be used as pontoons? I think so. With but little additional cost per boat they can be arranged for use as pontoons, and with two whale boats a bridge 30 feet long and 10 feet wide can be erected. Such an arrangement as this would be of much service if landing where the sea is not too rough, as also in crossing small rivers and streams. These whale boats should be manned by the pioneers (artisans), who should also, in boat evolutions, be used to repair damages to the fighting boats.

In speaking of stoves (p. 331) the essayist mentions no particular stove, so I suppose he refers to the old boat stove. A more useless article of furniture it is difficult to imagine. One has been invented in Germany which cooks well, is light, and by a few changes could supply all that is required of a campaign stove.

As for disembarkation it is to be said that "circumstances alter cases," that at present we have but about four vessels to a fleet, and that the electric search light is comparatively new to us and not generally supplied to our ships, so that the remarks on this point help us but little at the present day. As to marches, the words, "the commander of the expedition will decide how the march is to be taken up," say almost all that is necessary.

In the remarks on quelling a riot the words—"*if forced* to fire on the mob, use ball cartridge, and never fire over their heads"—might be introduced. A few lives sacrificed at the beginning will save much trouble and much bloodshed.

In conclusion I must say that I can see in the essay no definite plan of organization. For the success of the Naval Brigade it is necessary that it should be under a permanent head; that it should be governed by rigid rules,

for the carrying out of which commanding officers should be held responsible. Until this is done we are bound to have a different way of drilling in each of our squadrons, varying according as the ideas of the commanders of these squadrons vary. Uniformity in drill, strict attention to the firings and skirmish exercises, and continual practice are necessary before we can expect to realize anything like a perfect Naval Brigade.

Lieutenant COLAHAN.—*Mr. Chairman and Gentlemen*:—In regard to increasing the number of men allowed to a company, I consider the present number—thirty-six—as the one most conveniently supplied from the gun divisions of ships of any size. I consider this number also as a maximum for the artillery sections with limbers. I do not think it advisable to arm all the artillery force with the rifle—one half would be quite sufficient. Men in heavy marching order would have quite enough to carry without the rifle; there should be at least half the section as unencumbered as possible, so as to be able to do good service at the drag rope. These could be armed with revolver alone, while the other half would be armed with the rifle as infantry support. The latter could assist, if necessary, at drag rope and relieve the regular numbers stationed at the ropes.

I believe that some form of bayonet is necessary, and suggest a knife bayonet somewhat after the style of the Spanish machete, though not so large, say about ten inches long. This would be serviceable as a bayonet as well as for clearing any underbrush on landing or on the march, and would be of general usefulness as a knife.

The necessity for some means of transporting extra ammunition for Gatlings and small arms, as well as stores and cooking utensils, was made manifest in exercises of N. A. Squadron. A cart, two-wheeled, of the same gauge as the artillery carriage, provided with tongue and side drag ropes, should be issued to all ships. Independently of its use with the brigade, it would soon pay for itself in ordinary ship's work.

The idea of using capstan bars and sails for tents is a poor one, even for a camp of instruction. They are excessively unwieldy and heavy. At the camp at Gardner's Island they had to be hauled up the bluff with tackles, causing great fatigue and trouble, as the beach master, Lieutenant Belknap, can testify. They would be utterly useless on an expedition on shore. The shelter tent and rubber blanket would be all the protection necessary for the limited stay on shore required of the Naval Brigade.

Lieutenant-Commander HUTCHINS.—*Mr. Chairman and Gentlemen*:—The difference of opinion expressed by Lieutenant Mahan on the essay calls for a few remarks in reply.

In the first place, it is not necessary to change "the orders in the tactical books," but to confine ourselves to *tactical language*. I very much doubt if any fighting will be done hereafter without ammunition passers and carriers. At present we have no facilities for making up an ammunition train on shipboard, and somebody must carry ammunition. An examination of the essay

will show that I have sifted the words of General Von Kraft, as well as those of Captain Walter H. James, referred to by Lieutenant Mahan. The essay states, "Extra belts can be filled with cartridges and packed away in canvas bags, to be served out in an emergency." I hold that the belts filled serve the purposes of the Naval Brigade better than filling men's pockets with ammunition.

Lieutenant Mahan states, "The artillery company is *much* too small; sixteen men to the piece and seven additional for the limber would make but sorry work on the march. In the Egyptian campaign, a crew for a Gatling gun was composed of thirty men, and in addition thereto four mules." Commander Goodrich, who is authority on the Egyptian campaign, 1882, states that "the actual crews were each of 24 men,"—just one more than I have allowed in my organization. In the Egyptian campaign fourteen of the men in the gun's crew were armed with rifles, the rest of the detachment with cutlasses and revolvers. Twenty-three men to an artillery company appears to be about the number necessary. Were we to go on an expedition like the Egyptian campaign, referred to by Lieutenant Mahan, we would do exactly what the English did at that time—provide mules or horses to drag the artillery, and increase the number of men at each piece, to be used as *stretchermen, mule and baggage guards.*

When General Von Kraft referred to a company he did not mean forty-six men, neither did he mean sixty men; the German infantry company is more than double the size of the average ship's battalion of infantry; dividing the company into four sections, there is an officer to command each. Lieutenant Mahan states, "It is easy to say land so many men, but the thing is to detail them to their ships according to their rates. With such a detail made out, an admiral or commander of a fleet could tell at a glance just how many men he could land—that is, how many companies and pieces of artillery .... At the present time too much is left to the executive officer." The Bureau of Ordnance puts on board each vessel of the Navy a fixed number of small arms, according to her class, also so many pieces of artillery; consequently, to detail the men is one of the easiest as well as one of the simplest things an executive officer of a ship has to do; in fact, the Bureau of Ordnance settles this matter, and any admiral would know how many men each ship will land by a glance at the ordnance return of arms, guns, etc. The executive really has nothing to do with the number of men the ship is to land; he has but to use all the small arms (rifles) and the guns put on board for the artillery.

By reference to the essay we will find the following on blankets: "There is no reason why men should not be furnished with light canvas knapsacks for carrying blankets and clothing." One of the latest German naval expeditions, to Witu, August, 1885, the men carried no knapsacks. Notwithstanding "the recent orders issued to the armies of France and Germany, this way of carrying the blanket is relegated to obscurity," as stated by Lieutenant Mahan. I was not aware that the armies of any country carried their blankets in any other way except on the knapsack; in fact, I was under the impression that the relegating spoken of by Lieutenant Mahan occurred

more than a quarter of a century ago. Again, referring to the essay, we find it states, "Experience teaches us that without them (knapsacks) there is little comfort either in the camp or on the march." (In the camp they are used as a rest for the head.)

Every one knows that steam launches cannot reach the beach, and how we are to land the marines in them dry-shod I am unable to understand. When the marines are not able to pull themselves they should be landed by the reserves.

Again, a careful perusal of the essay would have informed my critic with regard to the tents, that I have provided for landing a force fitted out with what we now find on shipboard and will find for some years hence. At the same time I have also, in many instances, suggested what I thought would be a better equipment. Quoting from the essay: "For a prolonged stay on shore, application for tents to be supplied from the Army would be better. There is no reason why each vessel in the Navy should not carry several tents instead of so many useless and spare sails." With regard to the tarpaulin, I have camped in a swamp on soft wet ground, three of us sleeping on one for a week, and I found it excellent. Of the "old boat stove," of which Lieutenant Mahan says "a more useless article of furniture it is difficult to imagine," I shall quote from the report of a landing exercise by the commanding officer of the U. S. S. Swatara, 1882: "The boat stoves (two, launch size) proved amply sufficient for the needs of the party (103 officers and men). As but little previously was known of their capabilities, there was instituted a series of experiments to develop them. Boiling, broiling, frying and stewing—in fact, every feature in a culinary way, with the exception of baking, was successfully accomplished." Could any more be said in their favor?

Two surgeons and *three apothecaries*, as stated in the essay, I believe to be all that are required for the brigade.

Lieutenant Mahan states, "I wish to say that I gather from this essay that the artillery is to be drilled only as artillery and the infantry only as infantry," etc. A careful reading of the essay will convince Lieutenant Mahan that this is not the idea, and that there is one point on which we do not disagree. Quoting from the essay: "But, as the crews of two guns combined form one company, they could be landed as such if desired from those ships that would under ordinary circumstances land two pieces of artillery with limbers. The Ordnance Manual already requires that the crews of the howitzers and machine guns shall be united so as to form an infantry company and be drilled as such."

When our ships are equipped with limbers, the remark, "Limbers will always be landed with pieces," will apply. Continuing to quote from the remarks of Lieutenant Mahan: "As to shields for artillery, if these shields can be made a part of a gun carriage, serving to support the ammunition boxes when on the march, have them by all means." Lieutenant Mahan having made a cast-iron rule that "limbers will always be landed with pieces," he will admit of my shields as part of the gun carriage if they will serve to support the ammunition boxes when on the march. If you have limbers, ammunition

boxes go on them, and *not* on the gun carriages. Of course, if you are going to load down both the gun and limber with ammunition, it will be necessary to have larger gun's crews, and larger than the English had in the Egyptian campaign, for *they* carried their ammunition on the limbers.

In speaking of the electric light, Lieutenant Mahan states that "the electric light is comparatively new to us and not generally supplied to our ships, so that the remarks on this point help us but little at the present day." About one-fifth of our cruising force have been and are being fitted with the electric light. It is one of the most important adjuncts with which the Naval Brigade can be equipped. It is now being experimented with at the War College, and I can speak from experience in Egypt that it is invaluable to a landing party, when used from the masthead of a ship.

In concluding these remarks, I regret that my plan of organization is not definite enough to be seen from Lieutenant Mahan's standpoint. I appreciate his friendly criticism, which has brought up some points that I had supposed were generally known throughout the service. Criticism, particularly of a professional subject, can carry no weight with it, however, unless sustained by something beyond the mere statement of a difference of opinion.

NEWPORT BRANCH,

OCTOBER 12, 1887.

Rear-Admiral S. B. LUCE, U. S. N., in the Chair.

Commander BAINBRIDGE-HOFF.—*Mr. Chairman and Gentlemen:*—My remarks can hardly be termed a discussion of Lieutenant-Commander Hutchins' essay, but I am led to make the following remarks as germane to the subject. Mr. Hutchins places his boats to land in line. This means varying speeds and different instants of landing. Some boats will be under fire longer than others. The quickest way to get your boats in and have the crews land together is to come in columns—three or four of them—towed in by the steam launches. These launches should carry Gatlings, and then we would have machine-gun boats leading in with quick fire. The tows should cast off and the boats land in groups on the beach, before the water became so shoal that the steam launches would be in danger of taking the bottom, which they should never be permitted to do. Steam launches should never be used to carry men, and should have a Gatling or rapid-fire gun which is not to be landed. They must be the gunboat flotilla to protect the landing.

In regard to manning boats for landing, I believe in the "platoon system"—the system of sixteen. Not only should the landing bill be founded on it, but ALL bills on board ship should be founded on this system. It is a nine-inch gun's crew; it is a boat's crew; it is half a company; it is a howitzer crew, and an engine-room watch. It can handle a sail, it can clean a part of the ship; and if we adopt the newer system for supplying rifled guns—i. e., suppressing

the powder division—it forms a chain from magazine beside the gun's crew. It should have always two leaders associated with it—a boatswain's mate and a quarter gunner. All rates, such as captain of top, coxswain, ship's corporal, should be abolished. A ship should be entitled to so many platoons. Each platoon should be composed of four landsmen, six ordinary seamen, and six seamen. There should be one officer allowed to each platoon.

Mr. Hutchins puts his artillery boats in certain positions. This I consider bad, as it makes a hard and fast rule. Artillery boats, confined to arms firing larger ammunition than shoulder rifles, should be placed where needed. Gatling guns should be considered an infantry arm.

Lieutenant A. C. DILLINGHAM.—*Mr. Chairman:*—In considering or discussing the very able essay by Lieutenant-Commander Hutchins, I begin by agreeing with him in this, that "there has been, and always will be, some opposition by naval men to the Naval Brigade, and to the landing of sailors for operations on shore."

That every squadron should have an organization capable of operating on shore in case of necessity has been demonstrated not only by the navies of foreign countries, but since I have been in the service, by our own navy; for instance, the operations of Admiral Bell at Formosa in 1867, of Admiral John Rodgers in 1871 at Corea, and again more recently by the operations conducted on the Isthmus of Panama. There may have been opposition on shipboard by the sailors to being landed as infantry, but the experiences we have had in the North Atlantic Squadron show us that to-day the men of the squadron consider it just as much their legitimate duty as the great gun drill or the crossing of top-gallant yards at colors.

Lieutenant-Commander Hutchins has observed with great care the most important element in connection with the organization and landing of a Naval Brigade; for it is only by the strictest attention to detail, as he says, that the success of the landing can be insured. The question of landing a Naval Brigade allows of so many circumstances that will govern the details, that I do not believe any positive rules can be laid down that will satisfy more than one case. All that we can do is to lay down the general principles, and by practice ashore under different circumstances be better prepared to meet an emergency. The details for an expedition should be most carefully considered, and once made should be strictly adhered to.

The squadron of the North Atlantic Station has greater facilities for carrying on the requirements of a Naval Brigade than any other squadron we have. It has our own shores to land upon, and has easy access to materials, so that it may be considered *the* squadron where such an organization should be perfected by practice. It would add much to the efficiency of our drills in this respect if we had some permanent place where all the equipment necessary for the Naval Brigade could be kept. Here the squadron could assemble and go into field for such drills or operations on shore as the commander-in-chief should think best.

I speak of this for the benefit of those whom I have heard criticise adversely

the brigade drills of the North Atlantic Squadron. They have said that "too much attention was given to the Naval Brigade—too much weight was given to its importance." These officers I believe to be in error, when we consider that the drill is a necessary departure from the customary drills of a man-of-war's man. If we consider the actual practice we have had in landing the brigade for drill, it has not amounted to more than is necessary to show those concerned that an organization of this kind is possible and efficient. There is something to be said, too, in favor of the parades or displays we have had; though tiresome to us in themselves, they have nevertheless brought the sailors before the public, and have allowed the public to realize that we still exist. We are obliged to patronize the public, and to allow the taxpayer to see that his money is expended for material.

The organization of the battalion on board ship should be, as far as possible, the key to the organization of the brigade. But the battalions of the different vessels of a squadron differ so much as to the number of men composing them, that a strict adherence to ship organization is not always possible.

The first point that I take issue with the essayist upon is this one: "In combining the battalions under one head, each ship's battalions should *land* and fall in together." Under these conditions the battalions of the different vessels *land*, and after landing the brigade is formed. This might be done if the landing is unopposed or not under fire; but if the force is to be landed under fire, such a plan I should consider almost fatal. Upon landing, the companies would have to go to the positions they would occupy in the battalions, and it might be that a company upon the right of the line would have to proceed to the left, on account of the rank of the commanding officer. Upon landing when opposed, it is necessary to obtain and maintain a position as soon as possible. Such a state of affairs as I have spoken of would be confusion, hence delay. Such a condition is by all means to be avoided. A brigade might be landed in this manner if unopposed, with plenty of time to organize ashore, but why have more than one system? If we always land as if opposed we are always prepared.

The organization of the brigade should take place in the line of boats, before going under fire, so that when the companies leave their boats they are in the proper positions in the battalion to which they belong. This is accomplished by each boat, after leaving its vessel, taking that position in line which would be occupied by the men it carries, in the brigade. A map of "order before landing" is made and distributed among the vessels. The position of each boat in line is here indicated, and the officers to be landed know exactly where to go. It is just as easy for boats of battalions to find their places, forming the brigade in boats, as to find their places as described by the essayist. This is the practice in the North Atlantic Squadron and it has worked to perfection. Upon landing there has been no confusion. The brigade was *formed*, and an immediate advance could be made.

I agree with the essayist, that the size of a company of infantry landed should be consistent with the number of men in a division aboard ship, and that men landed should be commanded by the same officers that they are under

on board ship. He decides, however, that the size of a company shall be 20 files, with 2 guides, 2 file closers, and 2 ammunition passers; total, 46 men. There is no division aboard any ship in commission in our service, and less likely to be one in the future, on account of the less number of men required to man a modern gun, that can supply an infantry company of 46 men, unless we except the powder division or the engineer's division. For a company of this size men would have to be drafted from other divisions, thus destroying the principle laid down in the essay, that officers shall command the same men ashore that they do afloat. I suggest that a company be composed of 16 files, with 2 guides and 2 file closers; total, 36 men. The 2 file closers are not necessary, excepting to be used as ammunition passers or carriers when so required. It is only under certain conditions that ammunition passers are required. It must be a very long and continued action when a man will exhaust the 80 rounds carried in his webbing belt, if he is under proper fire discipline. During the whole time till ammunition passers are necessary, these men, as detailed by the essay, do nothing. The file closers, when the time arrives, can be detailed to pass ammunition, and also as carriers, when their rifles will make excellent supports for material carried. A company of 16 files can be broken into platoons, which is not the case with one of 20 files.

From the number of field and staff in a brigade of 20 companies of infantry, viz., 12, I should say that the essayist intends a battalion to be composed of 10 companies. It will be a long time before we have a squadron afloat large enough to land 20 companies of infantry besides the artillery. The North Atlantic Squadron, about the largest we have, in order to leave the vessels efficient, able to move, or to go into action, can land but 11 companies, and these of only 16 files. I think that a battalion of infantry landed should not consist of more than 6 companies. This battalion can be manœuvred in three divisions. Such a number of men can better be kept in hand, and more battalions are available for distribution on shore. I think it is not always desirable that the commanding officers of battalions should be the senior executive officers, as detailed by the essay. With the limited number of officers sent to vessels this plan of detail is good, but some officers have more aptitude than others for such service or duty. I believe a better detail would be one made by the commander-in-chief. The objection I see to this plan is that it excludes from brigade duty all officers senior to the detail.

In considering the plan of "order before landing," I see no good reason why the skirmish lines should be in boats, in advance of the main body. It gives more mass, consequently a better target; though it has the advantage of shortening the front. Supposing the whole front of a brigade could land on one beach, I suggest that the skirmish line be composed of the right company of the first battalion and the left company of the second battalion, where there are only two battalions of infantry, as in the brigade of the North Atlantic Squadron. When the signal, "Skirmishers advance, land, and deploy," is made, the boats containing these companies pull to the shore, and, upon landing, the right company deploys to the left, meeting the left company, which is deployed to the right. By this means the flanks are reached the sooner and the front covered

at once. The officer commanding the skirmish line will of course handle his line so as to cover the line of battle taken by the main body. The legitimate duty of the marines should be the first skirmish line; but, until they are capable of pulling and transporting themselves, this is impracticable. I see no reason why the marines should not be instructed in boat pulling and boat sailing. The best distribution at present for the marines is among the boats from their respective ships; they land with the main body, and after forming, proceed at once either to relieve or reinforce the first skirmish line. Putting them in the boats to be pulled by the men of the reserve, as suggested by the essayist, would cause confusion by separating this part of the reserve from the main body. If the first skirmish line is relieved, they assemble upon the battalions to which they belong and in their proper places.

The essay makes a rule for the position of the boats containing the artillery. There can be no hard and fixed rule for the position of the artillery, unless we consider the Gatling guns as a part of the artillery. These guns should invariably go with the infantry. As soon as the artillery is on shore the Gatling guns should be sent to the battalion commanders, who should place them to the best advantage with the infantry. Should the vessels of the squadron be able to clear and maintain a clear beach, then the artillery would form a second line and land after the main body, taking such positions in rear of the main body as the topographical features of the landing present. We would not attempt to drag artillery up a bluff, nor land it in the face of outlying rocks or shoals. Places should be selected where the guns can be landed with the least trouble, considering, of course, their future position after landing. It might be necessary for the artillery to be put in advance of the line, in event of the vessels being out of range and the contour of the shore being such as to prevent an enfilading fire. I mention these points in my endeavor to show that there can be no fixed rule for the position of the artillery before landing, it depending upon the circumstances of each particular case. The balsas now supplied make excellent rafts, and one should be towed astern of each artillery boat, to land the guns on if necessary.

I think that the proper use of the steam launches is not appreciated in landing the brigade. Generally they are loaded down with music and marines; they take the ground early, and in the endeavor to get them nearer to the shore they are put out of action and use by being hopelessly aground. The steam launches are the most rapid means of communication between the shore and what would be ordinarily the base of operations—the squadron. The steam launches can be used to advantage for towing, but they should be free to cast off before grounding, in order to be on hand to haul off the beach the heavier boats that cannot be gotten afloat by their boat-keepers. It is a most important consideration that after the boats have landed their men they should be ready, as soon as possible, to re-embark them. We have had in this squadron numerous cases of steam launches being put out of service by grounding. I would place in the bow of each steam launch a revolving cannon or a rifle howitzer. They should carry only the men necessary to work these guns, and the running crew. After they have done the duty of towing, if thus

armed they would make an efficient patrol for the beach, and by their rapid moving power could be employed to cover necessary points within their range. At the operations on Coddington Point, had the steam launches been so armed, it would not have been necessary to weaken the artillery force by sending a platoon to cover the retreat of the brigade to Coaster's Island, as they could have taken, in that instance, such positions as to have performed this service thoroughly. A steam launch towing artillery boats, one on either side, would present an excellent and rapid-moving battery of three guns. The steam launch should carry the spare ammunition, which should be put ashore by some of the lighter boats before reaching shoal water. Of course, in operations at a distance from the squadron, ammunition and stores would go with the brigade; but in operating near the squadron, the steam launches could carry to the shore stores to be landed by the lighter boats, and these would be protected by the guns of the steam launch.

In landing the brigade, the boats are already loaded down with men and such articles as are absolutely necessary to be landed at once. I would say it is only the men and such articles as may be immediately needed that should go in the boats. The stores and spare ammunition should come in later, after the landing is effected. For the rapid and safe landing of these articles the steam launches are available. Boats to carry the companies ashore should be as light as possible, for quick transportation and for getting in close to the shore. I would exclude from these boats all other articles than the entrenching tools.

The signals used should be of the simplest, and as few as possible. The boat carrying the commanding officer of each battalion should have a staff and a set of signals to be used if necessary. Each boat should be provided with answering pennant and tactical signal book. Enough signal men should be landed to allow two for each battalion and four for the brigade commander. In landing to operate near the squadron we have found that but few signals are necessary, as for instance:

No. 1 exhibited means, Forward.

No. 2 exhibited means, Skirmishers advance, land, and deploy.

No. 3 exhibited means, Main body land.

No. 4 exhibited means, Artillery commence firing.

No. 5 exhibited means, Artillery land.

No. 6 exhibited means, Reserve land.

All other signaling was done by the wig-wag flag. I see no reason why our men should not be instructed in erecting telegraphic communication. Such knowledge and material for its use might prove of great service.

It is of the greatest importance, when action takes place near the landing where there is no cover, that after the advance line is maintained the brigade should be protected by entrenching, particularly in event of retreat. To effect this in any reasonable manner or time requires, we have found, the efforts of the entire force left. The number of pioneers landed is only sufficient to form, perhaps, the leaders for this work. They should for this reason go in the boats containing the companies to which they belong, and be prepared to

carry, where needed, the entrenching tools brought on shore. When landed, they should remain at their boats till these implements are landed, and under the direction of the beach master transport them where they are required for use. The essayist, in the combination of the units (ships' battalions) to make up a brigade, cuts down the number of pioneers as landed with the ships' battalions. This I think a mistake, on account of the work that might have to be done by them. To be of any practical use they must be of sufficient number. At all events, whatever the number of pioneers, signal men, or whatever else, that number should land for that particular purpose, and not be liable to change at the landing.

Stores and spare ammunition to be landed can be handled by the boat-keepers assisted by the company cooks, as far as putting them ashore is concerned. After this, for transportation from the place of landing a working party would have to be detailed from the battalions, so many from each company. If the action is to take place near the place of landing, no stores should be landed till the landing is effected and sure of being maintained. If at any distance from the landing, the stores should be carried to the means of transportation by the working parties detailed as I have said. The question of maintaining supply is a vital one, and a neglect of this would cause failure.

We have these facts to deal with if we consider the Naval Brigade without co-operation. The squadron must be left efficient, capable of moving and of fighting. We have so many men ashore for the purpose of the expedition: with these we must make the best disposition possible under the circumstances. The supply train must be sufficiently guarded, and the men to handle material must be available. The commanding officer of the brigade will decide the best means of doing this, the means depending upon the circumstances of the case he has in hand. Cooks should be detailed, one for each company of infantry and one for each platoon of artillery, this force increased by a detail of one assistant cook from each company of infantry and platoon of artillery when in camp or bivouac. These cooks, on the march, should be with the quartermaster and commissary, to act as a guard and assist in handling stores.

As far as the infantry is concerned, I see no reason for any change from the army tactics. The evolutions employed should be of the simplest character, and the method of deploying by numbers recommends itself as leaving an entire front for the main body after the skirmish line has been thrown out. The simpler company movements of forming column, and from column forming line, are quickly acquired by the sailorman, and make up with the skirmish formations about all that is necessary. In fact, the company commanders will be depended upon to a very great extent, the battalion commander giving them directions as to what is to be done.

The bivouac of the brigade (Plate III.) is a system well planned, excepting that all the artillery is parked to the rear. The main body certainly should not be without the Gatling guns distributed along the line of the most probable points of attack. I would place the Gatling with the grand guard, the rallying point of the outposts. Even with the front towards an enemy, I believe in a concave formation for the main body in bivouac, as a means of protecting the

flanks in event of surprise. In conclusion, I would say that the Naval Brigade should not be landed except when prepared for active service, nor without some problem to solve ashore. Under these circumstances the best instruction could be had, the men would become used to the weights to be carried, would learn how best to dispose of them, and with an object in view in landing, the interest would be intensified.

Lieutenant CLASON.—*Mr. Chairman and Gentlemen* :—On two points I cannot agree with Mr. Hutchins. I read in the essay, p. 307, "A company of infantry should be composed of 40 men, with 2 guides, 2 file closers, and 2 ammunition passers and carriers—in all, 46 men. Companies should not be too large and unwieldy; large companies could only be a question of economy of officers, and in this matter no navy to-day can afford to be wanting." I propose, instead of this, a company composed of 64 men, with 2 guides, 3 file closers, and 4 ammunition passers and carriers—in all, 73 men, with 3 company officers. Such a company would require in addition from 6 to 8 boat-keepers—an adjunct not mentioned by the essayist in computing the force to be despatched from the Atlanta. My reasons for desiring this change are these: (1) To have such small companies is contrary to the universal practice of every army of which I have read—a fact that in itself speaks volumes in favor of my proposition; it cripples the ships seriously by withdrawing so many watch and division officers; (2) unanimity of action is much more difficult of attainment; (3) the mass of such a company, 46 men, is so small, especially after being under fire, that its shock can produce little, if any, effect upon an adversary. An officer in command of a company sees an opening in the enemy's line—a timely attack may bring victory to our arms. He looks about him; 25 to 30 men constitute his available force. Now or never is the time; but 30 men are insufficient;—he sends word to the captains of companies to his right and left, and also to the battalion commander;—one captain thinks the chance hazardous, the other will not advance without orders—they hesitate: when the battalion commander, or his orders, arrives upon the scene it is too late, the enemy has seen and repaired his error, the chance is gone, and with it, perhaps, the victory.

The proportion of officers to men varies considerably in different armies, from 1 to 50 in the German army to 1 to 33 in our own army. Mr. Hutchins gives 23 men to each officer; I propose 24 men per officer, a lieutenant to command, with two juniors associated with him. These officers should be taken from the same divisions the men come from; I thus have the companies officered "by their own division officers, with whom they are familiar as well as known."

Again I quote from the essay: "Then, in a vessel of the Atlanta class, we would have from the crew 2 companies, 92 men, and two guns and limbers, 46 men, 4 pioneers, 4 ammunition passers and carriers, 2 stretchermen, 2 signalmen and 1 bagman, in all 151, out of a complement of 242 men, not including the marine guard, which would probably land 37 men, making a total of 188." No account is taken of the 12 to 14 boat-keepers necessary in addition, and

the 5 men to run the steam launch, which would generally tow the boats. This makes a grand total of 205 or 207 men and 9 officers. Even allowing that the complement was full (a thing which every naval officer knows is rarely the case), my experience proves that such a force *cannot* be landed and leave the ship effective, and in this opinion I am backed by every officer attached to the Atlanta to whom I have spoken on the subject.

I propose to land from the Atlanta 1 company of blue jackets (73 men), 1 gun and its limber (24 men and 12 G.), 1 platoon of marines and 2 sergeants (34), 4 pioneers, 2 signalmen, 2 stretchermen, 1 bagman or apothecary, 12 boat keepers, 5 launch's crew, with 3 company officers, 1 artillery officer, 1 marine officer, 1 engineer officer to command the pioneers: to land more men would render the ship inefficient. I have a total of 158 men and 6 officers as against 205 men and 9 officers mentioned in the essay.

Major W. R. LIVERMORE, Corps of Engineers, U. S. A.—In referring to my remarks at the War College this morning, Mr. Dillingham was correct in thinking that I said that in the manœuvres planned for to-morrow,* it was not expected that the troops would adhere to the formations and commands laid down in Tactics. I referred to Upton's Tactics, but did not mean to imply that Tactics should be thrown aside in the fighting formations. On the contrary, I think that is when Tactics are most needed; and it is one of the fundamental principles of the system I would like to see adopted, that it should afford a language as applicable to the irregular groups of a modern fight as to the rigid masses and lines of the past. It is quite generally admitted in the Army that Upton's Tactics are not applicable to a modern fight, and the illustrious author of that system was fully aware of its imperfections, and was at the time of his death preparing to correct them.

With regard to the company column, we must remember that it is the successor of the battalion column of former days and not of the old companies; and the same principle that reduced the battle unit from 1000 to 250 men will soon reduce it again to about 60 or 80, and with our present organization of 100 men we can count on about that number in rank. It is desirable to organize the regiments with 12 companies, not so much for the sake of having three battalions to a regiment as for the sake of having four companies to a battalion, and in time of war it would be well to add another battalion so as to make 16 companies in the regiment.

It would be well also to group the higher and lower units in fours, and all European nations are coming to this conclusion. Napoleon said that no man should be required to command more than four others. It is simple and better to describe all tactical movements on the supposition that each unit is divided into four fractions, and these descriptions will answer for any number that may be presented.

Troops are disposed upon an area having two dimensions—length and breadth; and the simplest manner of dividing a unit is to separate the front and rear and divide each into the right and left fractions.

* This refers to the landing of the Naval Brigade of the North Atlantic Squadron on Coaster's Harbor Island.—*Editor.*

In advancing to action under distant fire there is no formation better than the square of 16 men. There should be sufficient interval in every direction between the men to enable them to move and face without interfering with each other, and the groups should be separated by sufficient interval to avoid heavy loss from hostile fire. It appears to me from this evening's discussion that this grouping of units is that best adapted to the Naval Brigade, as well as to the requirements of the Army.

All foreign armies are simplifying their tactics so as to reduce the number of evolutions to a minimum, and to devote most of their attention to applied tactics to teach the troops how to take advantage of topography.

Infantry so fractioned and grouped is better disposed for the irregular operations of modern warfare. But whatever system may be adopted in the Army, it will be so flexible as to be fully applicable to any other grouping that may be required from time to time, for the organizations will seldom be complete, and the fractions of several units will be often united.

In organizing the Naval Brigade, the important principle is to preserve the hierarchy as far as possible, and I think that this should be adapted to the requirements of the ships, and that any system that may be adopted by the Army will be found to be applicable.

Commander C. F. GOODRICH.—*Mr. Chairman and Gentlemen:*—I regard the essay as a paper of great value to naval officers. When it is considered that the conditions of the competition limited the writer to 40 pages of the "Proceedings of the Naval Institute," it is remarkable that so much ground is covered, and covered so well.

Having been associated with Lieutenant-Commander Hutchins, and knowing his habit of mind, which is so well displayed in the essay, I feel it incumbent on me, in his absence, to meet some of the criticisms which have been passed upon his article, although I speak entirely without authority. The subject of the essay covers so many points that it would be remarkable if some were not overlooked, or if in some things the writer was not of our way of thinking.

In regard to Commander Hoff's criticism of the formation for landing, it is very true that the boats may not approach in line, and hence the exact form prescribed by the essayist cannot be carried out. But what of that? It is precisely what is to be expected in action, and our plan must be made for meeting such an emergency on the spot. This will be true in regard to any method of formation which may be proposed. Absolute regularity of formation and coincidence of arrival at the beach, however desirable, may not be obtained, but we should strive for them, and if not successful, do the best we can under the conditions that exist at the time of landing.

I differ with Lieutenant Dillingham in regard to the detail of officers to the command of battalions. I am very jealous of maintaining the prerogative of the executive officer. I believe that this does much to preserve a sound *esprit de corps*, and I do not think the executive of ships will be willing to resign important commands. It has always been the rule in the service that the executive officer should command expeditions sent on detached service.

Furthermore, I do not think that the men would have as much confidence in a strange commander as with one under whom they habitually serve, although the strange commander might, perhaps, be the better man.

Lieutenant Dillingham wants the material for landing the Naval Brigade on this coast kept at one point where the vessels could rendezvous from time to time for exercise. I cannot approve the custom of confining such operations to one place. On the contrary, I think that every ship should be so provided and her landing party so organized that she could, on leaving this squadron, for instance, go abroad and find her proper sphere of usefulness in any other squadron which she should join. In other words, I think that the equipment and organization of landing parties everywhere should be the same.

If I understood Lieutenant Dillingham rightly, I think him in error in diminishing the number of ammunition carriers; I think the essayist has, possibly, not provided ammunition carriers enough. The large expenditure of ammunition, due to the introduction of magazine rifles, makes the rapid and sufficient supply of ammunition of very great importance. Although the number of rounds now carried is large, they will be shot off so quickly as to leave the troops in the front without ammunition very much more speedily than was the case with the old-fashioned arm. Moreover, if any considerable distance is to be covered, it will be found impossible to count upon the possession of the regulation 80 rounds of ammunition upon the part of every man, for it is well known that armies on the march relieve themselves of weight whenever possible. Indeed, their route may often be traced by the cartridges which have been dropped by the soldiers in order to lighten their equipment.

Lieutenant Dillingham's remarks upon the function of the steam launch in this connection are admirable. They are based on experience, and they commend themselves to all interested in the problem.

I think this is a good opportunity to speak of the very indifferent system of signals by the use of bunting to which the Navy has been tied for so many years. The flags themselves, and the code for which they are utilized, have always been unsatisfactory, as it is barely possible to make out a signal at any distance except under rarely peculiar and favorable circumstances.

In conclusion, I wish to express my deep appreciation of the terseness of Lieutenant-Commander Hutchins' style and of the practicality of his suggestions. The latter exhibit a happy combination of study and experience. Indeed, the whole essay commands our admiration, since by the wording of the subject proposed it was made to cover almost the entire art of war.

Commander BAINBRIDGE-HOFF.—I think our signals are better than Commander Goodrich allows. We have fewer flags than any other nations, and our naked masts permit a four-flag signal to be as easily read as a three-flag, provided the flags are supplied of slightly smaller dimensions than now. Our Army and Navy Code, with its Morse alphabet as now adopted, is as good as any, and our signalmen can be put on the electric key. The Ortman lamp now used in some of our ships in this station is better than any foreign

lamp, as we can make more symbols from the nature of flash given to the eye by the Ortman shutter. The signal book has been thoroughly overhauled, and the new drill book, taking the place of the old tactical signal book, has passed the inspection of several boards—Mr. Hutchins being on one of them.

Lieutenant-Commander C. T. HUTCHINS.—*Mr. Chairman and Gentlemen:*—If there is any one subject upon which naval officers are most prone to disagree, it is the organization and detail of the Naval Brigade. The discussions of the essay by the able officers who have taken part show, however, that the subject is one of vital importance to the service.

I have quite expected criticism of my essay on certain points, more particularly on the size of the infantry company and the deploying of skirmishers by numbers. I believe that the latter has been given up by European infantry tacticians, who strive for the individual deployment of skirmishers in a fan shape; still, I do not know that there is anything better for the seaman, who does not have many opportunities for skirmish drill on shore.

In reply to some of the criticisms:—

In the remarks of Commander Hoff on my "order before landing" he suggests to place the boats in columns to be towed by steam launches, in which formation they lead in "to land," casting off the tow and forming groups, all of which is done under fire. When we consider how difficult it will be to control the varying speeds of these columns, not knowing the proper moment to cast off the tow, the depth of water, and grounding of steam launches, there is every reason why boats should advance and land in line.

One shot into a steam launch might disable her, the boats overrun each other, there is confusion, and the result may be predicted.

In the "Order before landing," the signal is made to "land," when the boats get to the beach, as soon as possible; the skirmishers having already landed, the artillery clearing the landing place by a cross fire from the flanks.

The line formation presents the least exposure to the enemy's shot, and I fail to see why boats under fire should be huddled together in groups, with the object for grouping wanting, at the same time making a good target for the enemy and interfering with each other's movements.

We are all familiar with the difficulties encountered in the disembarkation and landing of the brigade. At night there may be occasions, when the electric lights are used, to form the boats in the shape of a triangle, the boats advancing in the dark zones, the point of the triangle leading. Even in this formation there will be a time when the boats must form line in order to find room to land on the beach.

The nearer we can come to the simultaneous arrival of the boats at the beach, the more certain we are of obtaining a foothold; which is not obtained by the advance of boats by columns and forming groups. Boats should be towed in toward the beach by tugs or steam launches, but they should cast off the tow and form the "order before landing" before the advance is made.

Commander Hoff says that the steam launches should carry Gatlings. I

have it from the best of authority that "in Europe the Gatling is completely played out, and it should be in this country." Steam launches would be better armed with the 1-pounder Hotchkiss, the best all-around gun now in use.

Like Commander Hoff, I am in favor of placing the artillery boats where most needed, and this I believe to be on the flanks, where they will also interfere less with the command and the direction of the infantry boats. You cannot obtain the maximum cross-fire on the shore with the artillery in any other place, and to attain the greatest effect artillery boats must be placed in échelon formation.

Lieutenant Dillingham takes issue with me in my combination of the different ships' battalions, and says: "Under these [my] conditions the battalions of the different vessels land, and after landing the brigade is formed." I am sorry that I did not make myself clear on this point, for by reference to page 330 of the essay, under the head of Disembarkation and Landing of the Naval Brigade, I state that each company of infantry (seamen) lands in the two ship's boats belonging to the division, and that these two boats always keep together, and *must take the same relative position in the order before landing as the company holds in the brigade when formed on the beach.*

The object of the "order before landing" is to organize the brigade in the boats before it is landed, each company being in its two boats and opposite to the place it is to occupy in the line of battle on shore. Where the company lands it forms, and I have never heard of, nor much less have I ever seen, a landing made in any other way.

Again, Lieutenant Dillingham says: "There is no division aboard any ship in commission in our service, and less liable to be one in the future, on account of the less number of men required to man a modern gun, that can supply an infantry company of forty-six men, unless we except the powder division or the engineer's division." For his information I would state that the Lancaster has two gun divisions with each one containing more than 50 men, and that the forward and after pivots have together 50 men, the officer in charge of these guns to go with the company. When I left the Lancaster, some three years ago, her first division had 56 men, and the second division about the same number. I am not aware that her complement has been cut down. The Marion's second division has more than 50 men in it, and I take it for granted that every ship of her class, seven of them, has the same. There is no reason why nearly every small ship in the service should not have a gun division of 46 men, and every large one two gun divisions, with 46 men or more to each. The modern idea in the navies of Europe is to have an officer to each gun of any size on shipboard, ammunition having become so expensive that the firing with great guns must be kept under control. Why have small divisions under inexperienced officers, when they can be combined under an experienced one? The smaller vessels are capable of landing a company of infantry composed of 46 men; they would hardly be able to land two companies of 36 men each. Taking into consideration all classes of vessels, and being able to form one company of infantry from two artillery companies, I believe 46 men to be the most suitable number for the needs of the Naval Brigade. I am

aware that officers may not be able at all times to have command of the same men in the brigade organization, but it should be the object sought after. Modern tacticians divide an infantry company into sections, and the formation of the company and its movement by either flank remain to be brought out in a future tactics. A fairly well drilled man with the Lee magazine gun can fire away 80 rounds of ammunition in five minutes: could modern thought doubt for an instant the necessity of ammunition passers and carriers? Lieutenant Dillingham suggests that file closers be used to pass ammunition. File closers in the modern fighting line direct the firing of sections of the company; they are the most important men in the company, and must give all their attention to fire discipline. I will admit they are of no use for parades, but my belief is that two file closers are *not* enough for a company, judging from the company organizations of European armies.

Lieutenant Dillingham sees "no good reason why the skirmish lines should be in boats in advance of the main column." The skirmishers in advance (two boats' length) of the centre of the main body in light, fast boats, are opposite to a point where they are to land and deploy, or deploy by boat and land. The flanks of the main body are protected by the artillery, and probably by several ships of the squadron; therefore, in only very exceptional cases should the deployment of skirmishers be from the flanks. It would be a violation of a principle in tactics to attempt to cover a front of a line of battle by the deploying of skirmishers from its flanks, as suggested by Lieutenant Dillingham. It might do for the pomp of war, but it does not belong to any school of tactics. Lieutenant Dillingham also says, "it might be necessary for the artillery to be put in advance of the line" of battle. This would be a violation of a principle in the art of war, not to bring guns into action without infantry supports in advance.

I cannot agree with Lieutenant Dillingham in the use he makes of the Gatling gun. It is well known that in European armies the Gatling has been thrown out of service—in fact, the bullet-firing gun is practically abandoned for military use. England, like ourselves, being behind the times, is the only country in Europe that has bullet-firing guns incorporated in its military armament. All the other great powers of Europe have no bullet-firing guns either in their military or naval outfit, Italy excepted. In my essay I class the Gatling last in its usefulness for the Naval Brigade, and it is about in keeping with the Springfield rifle. There may be occasions when it would be advisable to have with the grand guard a few pieces of artillery—for instance, one or two 1-pounder Hotchkiss guns; but I am opposed to the mixing up of artillery and infantry in the bivouac of the Naval Brigade; both arms have their proper and separate functions to perform, and it might lead to confusion when forming line of battle in the event of an attack. In the bivouac the formation will depend on the nature of the ground, roads, etc. The inner line or main body, *with level ground*, should be somewhat concave toward enemy, but the outer line, pickets and sentries should be convex.

Lieutenant Clason takes issue with me on the size of the company of infantry, and suggests 73 men, his reasons being, "To have such small com-

panies (46 men) is contrary to the universal practice of every army," etc. I am aware that small companies are quite unknown in armies that have plenty of men; but I hold that the small company suits the purposes of the Naval Brigade, and that 40 files in a company are quite as common as 64 files, his own number; and the combination of the artillery companies is not possible with this number (64) of men to a company.

Again, Lieutenant Clason states that "205 or 207 men and 9 officers can *not* be landed from the Atlanta and leave the ship effective." Effective for what? Certainly the ship could bank fires and fight most of her guns, or keep under way and fight some of the heavier ones.

To quote from the essay: "The circumstances governing the work required of the ship during the absence of the battalion would decide if all the force or a certain number of companies should be landed."

With regard to "the 12 or 14 boat-keepers, and 5 men to run the steam launch," of which Lieutenant Clason claims I have "taken no account"—in extreme cases boat-keepers would have to be reduced to a minimum.

Admitting that men in the service are as efficient as the special service men at the Naval Academy, I fail to see why 5 men should be required to run a steam launch under the circumstances. We have been running 12 and 13 steam launches at the Naval Academy, some of them 40 feet long, and a Herreshoff 56 feet long, for the past two years or more, with 2 men all told to the former and never more than 3 men to the latter. "The 12 or 14 boat-keepers" can be cut down to 7 men. Now, one more word about "leaving the Atlanta effective." If you wish to fight her in the absence of the landing party, land but one company of infantry and one piece of artillery; but when the time comes to land all the battalion, I am convinced, notwithstanding what Lieutenant Clason says, that the Atlanta can do all that I have claimed. As an instance of what can be done in the engine and fire rooms of a ship, where the Atlanta would have to draw men from to work her guns in an emergency, I give the following incident: The monitor Lehigh was lying at Port Royal, S. C., when we were ordered to proceed up the Savannah River, where we anchored off Fort Jackson and hauled fires. The third night after anchoring, and by the time I could get on deck and take in the situation, the ship had dragged three anchors about one-eighth of a mile, a freshet having come down the river sweeping everything before it. With the turn of the tide the ship dragged again and fetched up on some heavy piles—obstructions in the river—the ship's overhang resting on them. It was now a question of which would win, tide or furnaces; for on the turn of the tide again the overhang would hang on the piles, and probably separate from the hull of the ship. But one hour and forty minutes remained to get up steam, with no engineer, two machinists—one a stranger—and two marines borrowed from another vessel—the marines had once worked in the fire room. All the Lehigh's firemen had been sent down the river to help another vessel of the fleet. Fires were started and steam got up, and in less than two hours the Lehigh was anchored out in the stream, with a cost to the Government of little over one barrel of oil and a few bulkheads used for the fires, with two machinists, two marines,

and four deck hands to pass coal, all told, in the engine and fire rooms to do the work. All this could have been done, and probably better, in war times. I still must claim that the Atlanta can and is quite able to-morrow, should the opportunity present itself, to do what I stated she could do in my essay, and leaving 82 men and 13 officers—a total of 95—on board. I do not claim the organization I have given in the essay for the Atlanta to be her habitual one, I only desired to illustrate what landing force a ship can organize when a large number of men are wanted. Had one-third of the men been landed from the English fleet at Alexandria, Egypt, in 1882, that city would have been saved from pillage.

The CHAIRMAN.—The Naval Brigade, its organization, equipment, etc., is still in an unsatisfactory condition, not so much as to the actual organization of the brigade itself perhaps, but rather as to how the men forming the companies of infantry of each ship are to be selected. The question really begins with the organization of the ship's company as the basis of all other organizations. Our thoughts on this subject are in a state of solution, as it were, and it is to be hoped that by means of these discussions they may crystallize into clear ideas, not only on this but on all other subjects of a kindred nature.

Our sailors will be called upon in future, as they have been in the past, to land as a military organization for military operations on shore. In this respect we do not differ from other navies. The English, French, and Italian navies are constantly sending their sailors on shore to co-operate with troops in belligerent movements—the English in Egypt, the French in China, the Italians in Africa. Our Naval Brigade should be so organized as to enable it to operate on shore with the utmost efficiency, and at the same time with the least inconvenience to the ships of the squadron. Moreover, the brigade should be landed frequently.

"It is a well known fact," says a recent writer on military tactics, "that for the first three years of the War of the Rebellion, there were more lives lost and property destroyed from mere ignorance than from any other cause. The object of all military training should be to prepare men for war. Drill, as a means of teaching discipline, as well as preliminary field movements, etc., can be taught anywhere; but the underlying elements on which the art of war is founded can be learned only by practical experience." These remarks apply with equal force to us. But, to drill with the best results, our organization should be as nearly perfect as it is possible for us to make it.

I believe I fully express the sentiments of the meeting in returning thanks to Lieutenant Hutchins for his excellent paper.

WASHINGTON BRANCH,

OCTOBER 17, 1887.

Commander A. D. BROWN, U. S. N., in the Chair.

Ensign W. L. RODGERS.—*Mr. Chairman and Gentlemen:*—In reading Mr. Hutchins' essay, my first thought was of the entire practicability of all its ideas, so that, with one exception, my remarks must be confined to details.

I think a change for the better might be made in the titles assigned to the officers of the brigade. The army titles appearing in the printed ship's battalion bills are objectionable, because the Navy Regulations assimilate them with certain naval ranks not usually held by the brigade officers, and when to a young officer attached to a small force we give the mouth-filling title of quartermaster-general or adjutant-general, it makes him and his office ridiculous. I think we may find a fitting military title for the brigade commander in the obsolete army title of brigadier. For the commanding officers we might form titles derived from the French "chef d'escadron," and call them battalion chiefs, battery chiefs and company chiefs. For the officers on the staff expressive titles would be brigade adjutant, battalion quartermaster, battery surgeon, etc.

In assigning the brigade to boats, Mr. Hutchins distributes the marines as sitters in boats pulled by sailors. This seems objectionable, whether the marines are distributed among the sailor companies or whether they have their own boats pulled by extra seamen; for in one case the marines are disorganized and in the other the non-combatants are increased. In the North Atlantic Squadron the marines row their own boats, and when we think that any landsman can soon learn to pull a good oar, and that landing will rarely be made in bad weather or in heavy surf, this plan seems preferable.

I now come to the only point upon which I strongly disagree with Mr. Hutchins. In the matter of tactics he speaks approvingly of Upton's deployment of the skirmish line by numbers; I think this idea cannot be too strongly deprecated. We must recollect that although this system is now twenty years old it has never been employed in battle, and that the experiences of the recent great European wars have been so unfavorable to formations of such a nature that its author was engaged upon a new tactics at the time of his death.

The necessities of modern fire tactics require the strictest control of the fire on the part of officers and leaders of all ranks, which can only be obtained by always associating the same officers and men together, and so exercising them in manœuvres and firing. This is particularly important in the case of the small squads of 10 to 15 men. It has also been found necessary to give to the commander of any given part of the fighting line the supports and reserves required to carry through his part of the action; so that commands should be organized in depth rather than in length. In the skirmish line by numbers these rules are violated; adjacent men in the line are unacquainted with each other, and the officers of the line are chosen by an arbitrary rule of odd and even. When the supporting lines are advanced they start in the same dis-

organized condition and without any connection with each other, so that mutual support amounts to nothing.

In the armies of continental Europe, each command forms its own firing line with supports and reserves, and the ultimate units on the firing line are groups of ten or fifteen men, under leaders to whom they are known and by whom they are always commanded. A German company (250 men) is divided into three divisions. In the development of the line of battle, one division is thrown forward to form the skirmish line, and as the enemy's fire becomes more and more effective the division subdivides until the skirmish line is formed, but each "group" (10–15 men) remains under the strict direction of its leader. As the line needs reinforcements, the men of each group on the firing line close their intervals and complete groups from the supporting lines are pushed into the gaps thus formed.

Upton's deployment of skirmishers by the flank, however, can be readily employed in such a way as to fulfill all requirements. If the company of our landing force is organized as suggested in the Ordnance Instructions, the platoon of 16 men should be regarded as the smallest tactical unit, and the men in it should always be the same, and should be constantly exercised in every kind of collective firing. If the companies are grouped together in divisions of two companies each, under the senior company chief, and the divisions in threes under a battalion chief, we should have a battalion of the size of the German company.

To form a fighting line with one or more battalions, we might begin with the battalions in line with each battalion in double column of fours, or massed in column of divisions, and advance until the enemy's fire begins to tell. A division would then advance to form the skirmish line, followed at 300 yards interval by a second division as support, with the third at a similar interval as reserve. The fighting line on beginning its advance, say at 2500 yards from good artillery, should separate into platoons, and when at a distance of some 2000 yards the platoons should deploy as they advance, according to Upton's tactics, but each platoon should look to its leader for all directions in regard to movements and firing. If the line is boldly pushed forward, it may not need reinforcement until between 600 and 700 yards of the enemy, when the losses of the line and a contraction of each platoon towards its centre will afford intervals into which the organized groups of the support may be thrown. The importance of preserving the organization of the groups and of teaching stragglers to attach themselves to the nearest group leader is considered of the highest in all military training abroad. In this way, all reinforcements should be absorbed into the firing line, and I think that by torturing Upton's deployment by the flank only a little, we shall find it equal to our requirements.

Lieutenant C. G. CALKINS:—It is always very easy to criticise an essay, and does not always require technical knowledge on the part of the critics. I suppose that is one reason why any one who joins the critics is sure to find himself in the majority. Mr. Hutchins has arranged his paper in a very methodical manner, and it is very easy to follow. A great deal of it is very easy to

agree with because it is what we have been taught and what we have tried to carry out a great while, without having any great amount of success; but I think the criticism just made by Mr. Rodgers, about the use of skirmishers by numbers instead of by the flank, a very sound one. For instance, extending the line of skirmishers to cover the front of the battalion until the enemy be flanked can be much better managed by sending detachments, companies or half companies, and keeping them under their own officers as far as possible, although it is not absolutely possible to keep a skirmish line under the control of any given officers.

I think Mr. Hutchins gives too much importance to the formation or alignment of boats. It is a mistake spending a great deal of time trying to arrange boats in line and make a formation which is apt to be drifted out of shape before completed, and then advance in that formation against the enemy.

As a general thing, the fire from small boats advancing against an enemy is thrown away. Possibly some long boats with Hotchkiss guns in their bows might do something towards clearing a beach, but the fire from howitzers and Gatlings from pulling boats is a mere waste of powder, and the fire of the men also is wasted. I think the landing must be made either where the enemy is not present or where a beach can be swept by artillery firing along a sandspit, or where the water on both sides allows the ship to get a raking fire on the beach. After they get ashore, Mr. Hutchins lays down the order of march very carefully, and it is entitled to a good deal of consideration.

The science of war is something that every one is not called upon to understand. I heard a French officer, who had been in a little engagement in Formosa, who had something to say on the science of war. He said they came face to face with a lot of Chinamen who were huddled about on the slope of a hill among the bushes, on the other side of a paddy field. The men landed from the ships, were drawn up, and wanted to get across and get at those Chinamen. He said, "We didn't know how to do it, and finally were obliged to retreat. We killed some of the Chinamen, but in getting off we capsized a boat, lost a Hotchkiss gun and a few men, and in fact, summed up in a few words, we were well thrashed simply because we didn't know enough of tactics to advance over that paddy field."

When we follow the error that has always pervaded our drill books of tactics, and omit all reference to the enemy in drill formation exercises on shore, we are laying ourselves open to exactly the same kind of accidents. Of course tactics is nothing else but handling men in the presence of an enemy, and the drill book which gives a formation that would be impossible in the presence of an enemy is making a very dangerous error. It is only necessary to take up the field exercise books of any foreign army and see that they begin at once in the presence of the enemy. In the German army they take the men almost before they know the manual of arms and exercise them in changing ground, in selecting cover, in making advances, etc., giving them the most active instruction of this kind in the first six months of their drill before they pass their first inspection. With Mr. Hutchins, I think that we had better not land at all for service until we can have some instruction in the art of handling men in the presence of an enemy, and get some experience in that art.

The Chairman:—In that connection we might recall the expedition to Formosa in 1867, when Lieutenant-Commander Mackenzie was killed. We had plenty of men there, but could not do anything on account of the country being so rough and densely covered with undergrowth. The question then comes right back to what Mr. Calkins has said, whether it is advisable to attempt anything of the kind. It seems to me, in this question of the Naval Brigade, that we are not very apt to meet the enemy as it is laid down in the essay. In the first place, we are not apt to have such a large number of men that we could safely go out and camp a long distance from the ships. In the instances which have arisen in the past, such as those at Panama and at Alexandria, after landing we were not far away from the ships. Until we get a very much larger navy than we have now we are not likely to have the number of men that Mr. Hutchins has put down in his essay.

Ensign Rodgers:—I have recently read of the expedition in which Lieutenant-Commander Mackenzie was killed. The trouble was that this party was sent down to avenge an American seaman's death, and they had no tactical object before them. The result was they lost a great many men by sunstroke; the country was very difficult, exactly similar to that where Lord Wolseley used a naval brigade in Ashantee. He (Lord Wolseley) had a force of three or four hundred men from the navy before the army arrived. He knew exactly what he wanted to do with them, and he used them so they had the utmost effect on the future campaign. He beat the savages very easily; burnt their villages and destroyed their crops, which exercised a great moral effect in the campaign which followed. He was enabled to do this because he knew how to employ these sailors, whereas our people out in Formosa did not.

Lieutenant Schroeder:—If I recollect aright, the cause of Mackenzie's death was from charging into the bushes where the enemy who shot him were concealed, which is likely to occur to any one.

Lieutenant Calkins:—I do not think the enemy were seen more than once or twice in the ten days. The brush was very heavy, and it was almost impossible for the men to keep any formation in the shape of a skirmish line, if you choose to call it so; every man had to be for himself, fighting behind trees and that sort of thing.

The Chairman:—Then the point seems to me to be whether under these circumstances it is judicious to attempt anything of the kind.

Ensign Rodgers:—I think the reason that Lord Wolseley did so much was because he knew just what he wanted; yet he used just the same material, the Naval Brigade. The operations lasted only a few days. There was no army in the country, it had not come. And the cases were precisely similar except that one started without any clear idea of what was to be done, and the other knew perfectly what was to be done.

Lieutenant Calkins:—It seems to me the same principle might possibly have applied in Corea. If the marines had been landed in a certain way, the Coreans must have abandoned their forts even before the Palos went past them.

Lieutenant Schroeder:—The Palos did not go beyond the forts during the landing. I was present in that campaign. The Palos and Monocacy ran the

gauntlet of the forts and came back, and ten days afterwards the landing was made from below the forts.

The Chairman :—The force was at no time at any great distance from the supports, was it?

Lieutenant Schroeder :—No. We were out of gunshot, but not very far. We were two nights and three days ashore. The Naval Brigade landed about 650 men. When we captured the citadel, a large number of the Coreans that were killed were chiefs of greater or less importance, which had some ultimate effect on the campaign, as Mr. Rodgers was saying of Lord Wolseley striking a blow that would be felt for a long time. And touching that expedition also I want to call attention to what Mr. Hutchins says about marines. On that occasion we practised our marines in pulling boats beforehand, and they pulled themselves ashore.

Ensign Rodgers :—I think two-thirds of the force of the ships were ashore?

Lieutenant Schroeder :—About 650 in all. I suppose the fleet numbered thirteen or fourteen hundred.

Ensign Rodgers :—Then the covering ships, the Monocacy and Palos, did not land any men?

Lieutenant Schroeder :—No :—at least not till the attack was over, I think.

Lieutenant Calkins :—I would like to know if the object was to kill the Coreans, or if the object was to occupy the fort?

Ensign Rodgers :—Well, the reports of that action say they needed half the force of infantry to keep back the Coreans who were trying to rescue those captured.

Lieutenant Schroeder :—Part of the force was used for that—about two companies. Some of the artillery was posted on the hill, after capturing it, to check the advance of a large body of Coreans, said to be 7000 at the time, though probably not nearly so large. We had the marines and one company of blue jackets on that outpost hill, I think. A good many of the Coreans escaped as we advanced, but about 250 were killed in storming the citadel.

Lieutenant-Commander STOCKTON :—I would like to say a few words upon a subject that may appear at first sight somewhat foreign to the essay ; but as it relates to its practical effect upon the service, I will not hesitate to do so.

From a somewhat hasty perusal of this paper it seems to me a sensibly written one, likely to be of practical service if its ideas are put into effect.

The essay is the result of the yearly offer of prizes by the Naval Institute, which have of late years, in subject matter, become more practical, and hence more likely to be of every-day importance to us. The subjects proposed of "Torpedoes," "Naval Brigade," "Changes Incident to the New Ships," etc., etc., all bear directly upon the daily training of our men and the proper use and manipulation of our fighting material.

But there is a link missing between the preparation and publication of these timely papers and their communication, duly authorized and shaped, to the service at large. At present our drill manuals, properly authorized, are very scanty in number, obsolete in matter, and confined almost entirely to one bureau.

When I speak of the drill manuals I do not refer to the many fugitive pamphlets, papers, and books issued in a semi-official manner from various bureaux, often at variance one with the other, and all lacking that stamp of definite and final authority which will allow us to use them on board ship as established service manuals. The result, however, of these various professional papers, reports of boards, and prize essays, issued with the very best and most laudable of intentions to meet the great want of modern and freshly revised drill books, is, to say the least, confusing.

Some one office or person or bureau should have the whole matter in charge, and by giving us authorized and appropriate drills, enable the service to have uniformity in its routine and its various exercises and evolutions. There is no professional and actual head of the Navy who directly controls the personnel of the service, and to whom the Secretary can go as the person responsible for the efficiency, training, and discipline of the officers and men. The results of the various inspections, imperfect as they are, are lost; no present stimulus of consequence occurs from them, no future permanent improvement can be traced to them.

Lieutenant RUSH.—Lieutenant-Commander Hutchins has given us the most valuable paper upon the subject of the Naval Brigade that has yet appeared. In looking over his essay, one or two points have suggested themselves to me, about which I should like to say a few words.

First, as to the matter of organization. The Naval Brigade being composed of the united battalions of two or more vessels, the battalion becomes the basis upon which the brigade is formed, and the efficient organization of the former means, to a great extent, the successful formation of the latter. I take up, therefore, for consideration the question of the organization of the ship's battalion. Mr. Hutchins has given us an excellent sample case in the Atlanta's landing party, and I think he has worked out the organization most admirably, but on one point I would suggest a change, and this is in the matter of primary organization. In stationing the ship's company in station, quarter, and boat bills, I suggest doing it on the basis of the battalion organization; or, to put it more accurately, having divided the ship's company into two watches about equal in strength, intelligence, and activity, make out the other station bills with the battalion organization constantly in view. I am aware that this plan of organization is a radical departure from old time custom, which regards the growing importance of the Naval Brigade as of doubtful expediency, and even our prize essayist himself, I see, stamps such a measure as "probably resulting in disaster." But with due regard for the weight of opposite opinion, I am still of the belief that the organization of the ship's company in its various station bills upon a qualified battalion basis (if I may so express myself) will tend greatly to the solution of one of the most difficult problems which our first lieutenants have to meet, viz., the question how to organize their various formations so that comrades may be kept together, whether on board ship, embarked in boats, or landed on shore, the same men always together and under all circumstances under their own officers; furthermore, I

hold that the station bills so arranged will in nowise conflict with the proper organization of the ship's batteries, boats, or fighting establishment, but, on the contrary, will render the "parent ship" more efficient because better organized. To elaborate fully this scheme of organization would be beyond the limits of this discussion, but I think the question one worthy of careful examination and argument. That it will meet much opposition I have no doubt, but that the plan, or something similar, will eventually be adopted, I think highly probable.

In regard to equipment and outfit, Mr. Hutchins has covered the ground so exhaustively that I think there is little left to be said. I would add, however, a few items of comment. Abolish the cutlass and pistol, and substitute the rifle, except in the first six numbers of the artillery sections, the pioneers, the ammunition party, and the hospital service, which arm with revolvers. Reduce the number of men in the artillery sections (light guns) to twelve and a quarter gunner. Do not abolish the drum, but keep it with the bugle as the best possible field music. Do not entirely put the 12-pounder howitzer out of commission, but keep an odd one on board of each ship for occasional service; loaded with shrapnel or canister against a mob, or for close work, as in street fighting, it is second in value to the Gatling, and superior for destructive effect to the 3-inch rifle. This last will doubtless be considered heresy by the advanced artillerists; I refer them to the reports upon the first battle of Bull Run and the comparison drawn between the destructive effect upon bodies of men of the firing of the Napoleon rifles and of the naval howitzers. The ammunition supply and its service, both for infantry and artillery, demand especial attention, organization and drill, especially on the fighting lines, when in action, and should be in charge of officers selected for their capacity for this essential duty. The same may be said for the hospital service, and particularly for the stretchermen and their movements along the fighting lines.

Finally, I beg leave to add a single word upon the subject of the exercise and drill of the Naval Brigade. Upon this point I am in perfect accord with the very able prize essayist; I think that every word he says on the subject should be absorbed and digested. He has struck the right chord when he votes to abolish the "pomp and circumstance" of war, the charming dress parade and review for the edification of the admiring crowd. The precision of the manual, the correct alignment of the columns, the cadence or length of the step, are matters of absolute insignificance to the rank and file of the Naval Brigade, as compared to their accurate marksmanship, to their knowledge of the piece, including its mechanism and care, and above all, to their individuality as fighting men. We do not require exercise in the elaborate tactical movements of battalion drill; on the contrary, confine this part of the drill to the simplest movements in line, in column, and by the flank. The drill we need is a practical exercise in the field of the movement of such a force when actually in presence of the enemy, and this is best found in the skirmish line and its development to the front by successive reinforcement from the main body and reserve into the fighting and supporting lines of battle. This drill should be altogether by bugle and signal, never by oral command. Add to this drill one for landing on

the beach in the face of fire, and another for returning to the boats under fire, with some exercises in advancing through an enemy's country, especially in heavy underbrush with the artillery, and a plan (which I have not yet seen well formulated) for street fighting, and I think we have enough food for powder and reflection without the dress parade and review. There should be no limit to the expenditure of blank cartridges. Commanding officers will find the success of such drills depends greatly upon the perfect understanding by each subordinate officer of the programme of exercise, which should be copied off in full detail and distributed to the officers before the drill, and never changed even in the most trifling particular.

The exercises of the North Atlantic Fleet at present in progress at Newport is the most important departure in the right direction which the "young navy" has seen. The benefit which will follow to the entire service from these drills afloat and ashore I think is almost beyond estimate. Let us hope the autumnal manœuvres of the Home Squadron will become an established fact, and that all newly commissioned ships will be required to participate in them before leaving for distant stations. It will then indeed become, as it now promises to be, a fleet of application and a school of practice for the whole service.

The CHAIRMAN.—That subject was the very thing I was thinking about on my way down here. The necessity for uniformity is something that is most essential, and we can never get it until we have some home in the Department for the personnel. The attempt that was made two years ago to have a Bureau of Personnel was one which it seems to me must be carried out eventually if we are ever going to get anything in the shape that we want it. Now take this very question of the battalion on board ship, it is the nucleus of the Naval Brigade. Every ship that you go on board of has a different organization, according to the best lights of the executive officer and commanding officer together, and the result of the thing is, that where there are so many different people to do the thinking, of course you are going to have differences. Those differences ought to be reconciled.

I have long been thinking over the idea that the battalion organization of every ship should be like that of every other, of course within certain limits. The small ship and the big ship could not be made exactly alike, but they could be made nearly enough alike, so that of half a dozen vessels every one could put men on shore who would know right away where they were going and all about it. There is no reason, it seems to me, why here in the Department there should not be knowledge existing of the force on board every ship and the force that ship could throw on shore. Take at this present time the case of the Adams going to Samoa. I venture to say there is not an officer in the Department, from the Secretary down, who knows what force the Adams can put on shore when she gets there, how long they could stay there, or anything about it. If they do, they must have heard it from a private letter from there; certainly there is no official way of getting it.

It has occurred to me that, possibly, by adding to the Board of Inspection a number of officers, junior in rank to those now there, men called upon to make

and officer the organizations on board ships—in other words, lieutenant-commanders and lieutenants—that it would be practicable to get some sort of uniformity in regard to drill. Now the Board of Inspection require, as I understand, certain things to be done when they go to inspect—where they get the authority from I do not know, but they adhere pretty closely to the two manuals that Mr. Stockton referred to, with occasional deviations, agreeing very largely with what the senior officer thinks ought to be done. Therefore it seems to me of the first necessity that these matters should be straightened out, and it would very materially aid in the reorganization of the Department, or at least diminish in some measure the evils under which we are now laboring, till we can get some different way of managing things. I do not suppose there is an officer in the Navy, from the highest to the lowest, that would not gladly hail anything of that kind; I mean of course on our own side of the establishment. But there are some things that, in reading this essay very hastily, strike me as very good; here is one, "the absolute niceties of the service should be abolished in the drill of the battalion." It is a mystery to me why so much attention should be given to the seams of the trousers and all that sort of thing. There is another point that Mr. Hutchins refers to two or three times, and that is regarding the necessity of drilling the marines as boatmen. It seems to me absolutely necessary not only that the marines should pull their boats, but that every man on board the ship should know how to shoot a rifle and hit a target and also to pull an oar.

Lieutenant Staunton:—That is called for by existing regulations—not the oar part, but the other part—the small-arm drill and target practice.

The Chairman:—It has been now some three and a half years since I have been at sea and the material we had to deal with was pretty hard material to get any results from.

Lieutenant Staunton:—I believe you can teach any man to shoot fairly well if he can see. A man may be careless, or he may be nervous because he does not shoot enough to get over his nervousness; but he can be taught to shoot fairly well if sufficient time and attention are given to the subject.

The Chairman:—It seems to me that we have got to have a revolution in regard to the duties of the people on board ship. Servants are there now primarily to attend to the wants of the officers. Now, my theory is that that should be a secondary consideration, and the wants of the ship of primary importance. In the first place, there are entirely too many of them. The commanding officer has a staff of three. Why in the world one man wants three others to wait on him is a mystery to me; in the ward room, also, it seems to me there are altogether too many; it certainly takes four times as many as there would be on shore to do the same amount of work.

Ensign Rodgers:—Well, the work is different to a certain extent; you can't organize the work as you can on shore; it has all got to be done at once in a limited time.

The Chairman:—There is a certain amount of force in that objection.

Ensign Rodgers:—You don't get the same class of servants on board ship; it takes two or three times as many to do the work that a good servant would

do on shore—the more you make sailors out of them the less use they are as servants. I would rather have one man in the ward room as a first class servant than two that could go aloft, perhaps, and furl a sail in a pinch, and pull an oar, and hit a target once in a while, but are of no use as servants.

The Chairman :—That is quite right, it was the very point I was coming to. By reducing the number of servants and using them for nothing else, it would require a very small number to do the work ; it would not be necessary to have so many.

Ensign Rodgers :—The ships would not require so many if they were not called away so much. They are liable to be called away in the middle of their work for ship's routine, drills, etc. The cook is likely to be called on deck and leave his galley half a dozen times a day to send down royal yards, when he may not be of the slightest use and when the whole dinner may be depending upon him. I thing it is better to reduce the number of servants and have them for that service and no other.

The Chairman :—I don't see why one steward and two cooks could not run the galley for all the officers. But they should have nothing else to do. That should be their business, and then the number of servants who attend to the rooms could be very much less than it is now. If I am not mistaken, that is what they do in the English Navy ; they have mess men and a cook, and their servants are generally marines who come in and clean up the rooms.

Ensign Rodgers :—I do not believe in that. I think it is bad for the men to occupy these positions. The essay speaks of the desirability of having a change in the drill. Unless I have been misinformed, when we sent the expeditionary force down to Panama, two years ago, the drill all went to pieces and the officers got up a little drill of their own on the mail steamers going down. It did very well while down there. I think this itself is a criticism on the whole business, that we have a drill which is more or less legalized, yet call half a hundred men together and they get up a little arrangement of their own altogether different.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

INFANTRY-FIRE TACTICS, FIRE DISCIPLINE, AND MUSKETRY INSTRUCTION, AND PRACTICE WITH RAPID-FIRING CANNON.

By LIEUTENANT-COMMANDER C. T. HUTCHINS, U. S. Navy.

Having had the honor to gain the gold medal of the Naval Institute for an essay on the Naval Brigade, and having, for want of opportunity, touched but lightly in that essay on the subject of infantry-fire tactics and musketry instruction, I desire to bring that important subject forward as it is now presented to us with improved arms, and at the same time I wish to include in the discussion the practice with rapid-firing cannon.

It is to be lamented that we are absolutely without any small-arm fire discipline and fire tactics in the Navy. That our system of musketry instruction should depend on the fancy of the commanding officer of any of our vessels of war, with the recommendation to use the incomplete Army system, and that the prize to look forward to is to redound to one's credit,—these, it seems to me, are sufficient to enable one to predict what the useful effect is of the musketry instruction as now taught in the service. Though our musketry instructions are faulty in the extreme, directions in our service for the exercise of riflemen and men at the rapid-firing cannon are numerous. Yet it is a matter of fact there is no systematic plan, except in a few instances, of teaching the men fire discipline under the most favorable circumstances. Our musketry instructions should be such as to effectuate the requirements of our (modern?) tactics.

The Army instructions in rifle-firing are wanting in the most important of all firings, volley or mass firing. Individual firing being the object sought after, the Army instructions are elementary.

The individual instruction being completed, the men are not taught the value and use of volley, group, and mass firing under the control

of leaders; and yet, in the elementary drills, the musketry instruction is all that can be desired for the seaman recruit.

To quote from the Army instructions of 1885, "If the *allowance of ammunition will permit*, the company commander should, if practicable, near the close of the target season, afford his command practice in *volley firing*. The object of this practice is not only to give the soldier instruction in a *class of fire that will, under some circumstances, be employed in action*, but also to make the company and subordinate officers familiar with the manner of controlling the fire of their command; to accustom the men when in ranks to the habit of relying upon the judgment of their officers as to the range and approximate adjustment of their sights, the extent of their fire, and the most suitable time for its delivery." For some unaccountable reason the Army still clings to the single loader, and volley and mass firing are not of so much importance with such an arm as with the magazine rifle supplied to our seamen, and in use by all first-class powers, with one exception, and now about to be adopted by that power. The days of the single loader are numbered, and it appears probable that our army will be the last to abandon it—perhaps not until the disappearance of the North American Indian. Its present retention by the Marine Corps is much to be regretted.

Individual fire was given up long ago in continental Europe, and I believe is now condemned in England. Neither afloat nor ashore must we hold to the idea that the average excellence of fire of the individual sailor is the test of his efficiency in battle, or that it is the established rule by which we may judge of the effective fire of the mass; therefore uncontrolled individual fire should not be used. It is only a few years ago that an English authority on the subject of infantry-fire tactics stated that independent fire of individuals was the curse of the English army; and this, I believe, was shown by the fire of the English troops in Egypt and the Soudan. Most certainly their firing has been unmercifully condemned by Major-General H. Brockenbury, C. B., who commanded in the Soudan campaign, "to the fame of the force he commanded."—To quote from his remarks on infantry-fire tactics, "I regret to have to say, and that is, they (British soldiers) cannot shoot. . . . Of course, we all know the enormous mass of lead that is fired away for every man that is killed or wounded, and what does that mean? It means that our soldiers are not trained to shoot as they should be." As our army system of musketry instruction follows very closely that of Great

Britain, and might be said to be about the same, and as the musketry instruction of our navy is based upon that of our army, it would be well to heed these warning words, and not follow blindly a system of musketry instruction that is condemned in every country in Europe. For the Navy we must adopt a system of small-arm fire tactics that is in keeping with the advanced ideas of the day—a system that will qualify our seamen so that they may be able to fire in masses or by volley—*concentration of fire*, and the controlling of it as long as possible. After men have been taught to point their weapons, their instruction should take that direction which will fit them to be controlled at all times in their firings by a petty or commissioned officer. A French writer, M. E. Simonde, in "De la Tactique des Feux et des Armes à Répétition," 1884, says: "Let us use fewer cartridges in training men to attain an accuracy of *individual* fire, which has not in war the great importance usually attached to it, and let us make use of them rather in teaching the leaders the employment of fire"—to habituate them simply to adjust their sights and to aim correctly and quickly after having loaded; devoting more attention to fire discipline, rather than to providing for a wasteful expenditure of ammunition caused by hurried independent shooting. I am not only speaking of the instruction of men for the Naval Brigade, but also for those on shipboard during battle, where mass firing or firing in groups will be more effective than individual fire, which is a waste of ammunition, waste of time and waste of energy. In close action individual fire will be forced upon us; there is no human power at this time that can control men in their firing and in the expenditure of ammunition; in the field, authorities give 400 yards as the limit, and the more raw the men the greater this distance becomes. And here again we must not only have the magazine gun, but fire-arms that will need no change of sight after getting within this distance (400 yards) of an enemy; fumbling with sights under fire, at close quarters, should not be permitted.

In a most remarkable and most valuable English work on the subject of infantry-fire tactics by Captain C. B. Mayne, R. E., we find: "The independent fire of individuals in the field is of little, and we may say of no value beyond 400 yards; the only really effective fire is that which proceeds simultaneously from a great many fires directed on the same point—that is, from *concentrated fire*. Mutual co-operation is the secret of success in war. Individual action is a waste of power, tends to panics, and is in every way to be avoided.

The fact of the matter is that only very few men are individually good shots, especially when under fire, and those that are such have their skill nullified in the field by the excitement of the fight and by not knowing the range exactly, the almost all-important point for accurate shooting."

Taking all these facts into consideration, it does not appear that we should be carried away with the idea that a dispersed order of fighting will win battles in the future. Clouds of skirmishers moving to the attack open the fight, but they have no cohesion in themselves; and there will be a time during every battle when large bodies of men under good fire discipline and the control of leaders, must be brought forward in order to gain the fight.

In the concentration of the small-arm fire on shipboard, let us take for example a group of men in the maintop of a ship; the order would be given for all the riflemen in the maintop to concentrate on a certain gun's crew of the enemy or any designated part of the ship, such as the conning tower, should it be like the Chicago's. To kill two or three men at five or six of the enemy's guns does him but little injury; but if you can disable or kill ten or eighteen men at any one gun, that gun is for the time disabled, not to speak of the moral effect produced; and with the secondary batteries of ships manned by small crews, a concentrated fire might possibly in a few seconds disable any gun by the killing off of the crew. We are all familiar with the fight between the warships Covadonga and Independencia, during the war between Chili and Peru, when the well directed musketry fire of the weaker ship played such an important part in her escape. To make a success of the concentration of fire and its direction under leaders, the groups or squads must be under the control of a petty officer, who should be under the direction of an officer of the ship. These squads or groups would be composed of not less than four nor more than sixteen men, and in the exercises the petty officer would be accustomed to handle these men, as well as take part in their instruction in firing and assembling at any part of the ship. In the instruction, the squads should be independent in their movements, and men should be detailed with each to provide ammunition—the supply coming from some designated place in the ship, always known to the leader of the squad. In the assembling of riflemen on deck from below, it is questionable if the custom of the service—having them form on the side opposite to the one engaged, in those ships that have bulwarks—is right, since they can be seen

and fired upon from the tops of an enemy's ship. In dealing with the sailor in our small-arm fire tactics, we must confine ourselves in our instructions, by devoting much time to the really essential things, and omitting those things that are of no practical use to the seamen in battle.

As the useful effect of fire does not depend on its rapidity, we may say that five rounds per minute is about the rate of firing with well drilled men; if in excess of this, the firing would become less accurate. At the present time we must deplore the want of effort in the right direction, and regret that the brain power should be devoted to obtaining a powder with greater initial velocity, instead of a powder that will vaporize immediately after firing, leaving no smoke, and permitting a firer to see an enemy at all times in battle. Such a powder has been in use several years in fowling pieces, and eventually must be adopted for use in our rifles. Those who have had any experience with revolving cannon know that it requires but 15 or 20 rounds to be fired in rapid succession when the gun is enveloped in smoke to such an extent as to hide the target from the gun-captain's view.* In all target practice it is very important that each shot be plotted, and that each man shall know where his shots struck the target. The plotting of each shot, with an explanation of the score, and the posting up of each firer's target, present it to the mind, and such an illustration is worth a cart-load of written reports and discussions on the subject.

For the purpose of plotting each firer's score, targets, Plate I, now in use at the Naval Academy, are found to answer all the purposes sought. Figure targets should not be used for teaching marksmanship, but for field practice they are indispensable. The explanations on these targets should, when necessary, call the firer's attention to the cause of bad shooting. It may entail more work on the officers of a ship; but the older officers should be given more time for the instruction of their divisions in the much needed fire discipline, the junior officers looking out for the day deck watches. We still find in the British Naval Gunnery Manual such words as these, that "the real exercises to cultivate the necessary dash and agility will be found in sail and spar drill." It is very doubtful if the ships of the future will be equipped with spars and sails to make sail drills of much benefit to the seaman; therefore, the time heretofore devoted to

*Smokeless powder, composed of prussiate of potash, chloride of potash, and sugar.

PLATE I.

RECORD OF PROGRESSIVE SMALL ARM TARGET PRACTICE.

NAVAL CADET, , CLASS. U. S. NAVAL ACADEMY, 188

DATE.	ARM.	DISTANCE.	ROUNDS. 1	2	3	4	5	6	7	8	9	10	TOTALS.		REMARKS.

TARGETS.

3d Class.

2d Class.

1st Class.

these exercises should be taken up in rifle and rapid-firing gun exercises, with the expenditure of more ammunition. It is surprising to know that our service is about the only one in which prizes are not awarded for good shooting. Sometimes the officers of ships subscribe sums of money and offer prizes, worthy countrymen joining in the subscription; but that we should have to do this to encourage good marksmanship is a sad comment upon those that direct our drills. Our seamen should be encouraged in their target practice by offering them rewards and prizes, and by creating among them competition trials with battle conditions. Our present system of carrying on firing drills has been in operation long enough to convince the most sanguine that it is fatally defective; and it may be traced to the fact that there is no one under the government of the Navy that is directly responsible for any firing exercise under battle conditions—the real object of all our work; and until we have a Board of Inspection with unlimited powers, just so long will we be wanting. The work of overhauling target reports, and furnishing to the Navy a system of drills and exercises, ought not to be imposed on any bureau. All reports of exercises, particularly firing drills, should go to a Board of Inspection, to be by them examined, and this Board should be held responsible that our ships are in a high state of efficient fire discipline. Their responsibility would be sufficiently great in itself to preclude the possibility of any want of proper attention to the development of the higher requirements of fire tactics and its practical necessities.

There must be no doubt of what the duties of such a board should be; drill inspectors would confine their duties to the inspection of artillery fire both great and small, and everything that pertains to the fire of weapons offensive and defensive which fit a ship for battle, and her crew for a hasty disembarkation for operations on shore. To carry out such a system of inspection, our ships must go to sea and be required, under the eyes of inspectors, to go through their firing exercises, to land the battalion or Naval Brigade, and to practice volley and mass firing as we would expect to be called upon to do in battle. The bitterest opposition should be shown to all drills at these times that are not complete by the use of powder under battle conditions.

Rapid-firing cannon demand much drill practice; and frequent firing under the actual conditions of fighting the guns in service is of the greatest importance. The Hotchkiss Gun Company have made a move in the right direction in devising an outfit of drill cartridges.

The drill cartridge gives the needed exercise which is required in full instruction to perfect the gun's crews in the firings and the handling of the guns, without the cost entailed by the expenditure of full service charges.

Plate II. gives a drawing of the drill cartridge. The drill cartridge is in shape and weight the exact counterpart of the service cartridge. The case of this cartridge is a rifle barrel chambered and grooved to correspond with the service magazine rifle. A steel base and extraction head is fitted to the bottom of the barrel; the body of the cartridge is made of hard rubber and the head of brass, thus properly distributing the weights as they exist in the service cartridge. In the base a small spring is inserted to hold the small-arm cartridge in place when loaded, as otherwise in handling it might fall out. In this manner, when loading the gun exactly as in service, a small-arm barrel discharging its regulation cartridge falls naturally in the axis of the bore of the gun.

A box containing twenty of these cartridges is provided for each calibre of Hotchkiss gun on a ship. In the box is also placed a drill sight properly ranged for the small-arm ammunition. In drilling a gun's crew it is simply necessary to put the drill-cartridge sight in place on the gun and load the drill cartridges, an operation requiring about half a minute. The cartridges may then be distributed in the service ammunition boxes, and everything is ready for carrying out every detail of fighting exercise *without a single deviation from actual fighting service.*

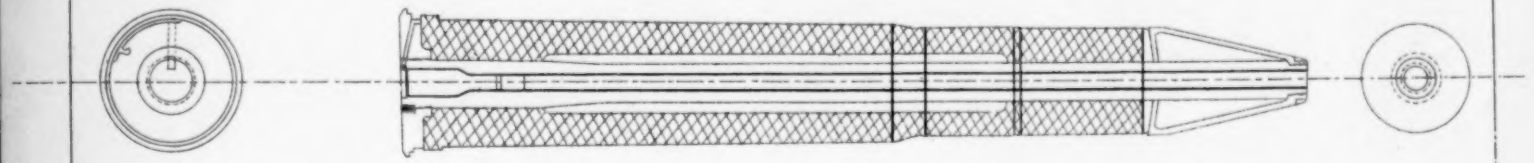
It will be seen that it is the tendency of European nations to obtain if possible all the conditions of battle practice in the exercise of men with small arms and rapid-firing cannon; and if it is so important with large navies, how much more should it be so with our own small force, and with very few, if any, men to draw from in war times. Drills, exercises, and training must be completed before a war is inaugurated, for it is then too late to discipline and perfect men in their drills, which is all the more vitally important with the rapid-firing cannon.

The facility with which riflemen can protect themselves on shipboard from the fire of an enemy, the greater accuracy of their fire, the absence of smoke (smokeless powder being used) and consequent full command of the ship and uninterrupted view of the enemy, put small-arm fire on an equality with that of the machine and rapid-firing guns, and more particularly so, as the value of machine-gun fire is yet to be proved. Often a machine gun will

Plate 2.

Hotchkiss Drill Cartridge-6 Pdr.

Scale ½ Size.



demoralize and drive away the crew of a large gun by a hail of bullets falling close around, striking carriage and gun, though few or even none of the crew are actually hit; this the writer is convinced occurred in the batteries on shore at Alexandria, Egypt, in 1882.

If skill in judging distances on shore is all-important, it is still more so on shipboard, where the objects aimed at advance and recede at great speed, as is the case with torpedo boats; therefore, men should be taught this exercise, or their fire will not be effective.

In laying out a scheme for small-arm target practice and instruction for the Navy, not only should the object be to develop fire discipline, with a knowledge of the arm and accuracy in its use with reference to our special needs, but we should also develop a true knowledge of the efficacy of fire when under the control of intelligent leaders—a fact not to be lost sight of when dealing with seamen, because of their lack of opportunity to attain the perfection of regular troops. Battle conditions should be assumed, and at no time should any firing take place unless some of these conditions are presented. Firing at targets hanging from a yard-arm is no instruction to the recruit. In the practice from the tops of a ship and from the boats, floating targets anchored at known distances should be used, and the same kind of targets when firing from the decks. A small boat protected by boiler plates and towed by a long line at good speed across a certain arc of fire, will give a practice that would be very useful against torpedo boats, though this practice could be obtained at any range on shore. It is the exception in our service to see any practice in firing from the tops—a class of fire from which we should expect good results, so long as ships carry fighting masts with protected tops. I am aware that there is danger in some ships of shooting away something aloft; but we might also say there is also danger of shooting oneself. In the practice with small arms the eye becomes accustomed to the use of sights, and any thorough system of musketry instruction would give to the seaman that accuracy in the laying of heavy guns so much sought after, and without which no ship is ready to give battle. General H. A. Morrow, U. S. A., on the subject of *rifle instruction and practice*, says: "It has done more to elevate the moral standard of the army than any other one thing. Temperance, abstemiousness, patience, perseverance and industry are cardinal social virtues, and it so happens that they are absolutely necessary qualifications of the marksman." It is well worth while to weigh these words carefully, that we may give more attention to rifle instruction and practice.

The frequency of accidents in the service on board ship after small-arm target practice might be reduced to a minimum if the drill instructors were compelled to report in writing after each firing exercise, that all arms had been inspected and that all ammunition unused had been turned in and stowed where it could not be gotten hold of without orders. Again, dummy cartridges should be nickel-plated, so that they can always be known by the most ignorant.

To attain any degree of skill in firing, constant practice is necessary; and to avoid too great expense, reduced charges should be used. In order to carry out this plan on shipboard, aiming tubes should be used, and a plentiful supply of ammunition and targets furnished to each ship. These tubes should be so mounted in the rifle barrel that all the conditions of firing would be the same as with the service cartridge, with the exception of the recoil, which could not be obtained.

The violence of recoil is a very important consideration with our present weapons, when a rapid fire is continued for any length of time; and it is very doubtful if a continued rapid fire of any accuracy could be kept up for a longer period than two and a half minutes, and then only with thoroughly drilled and experienced men. It may not be generally known that a great deal of bad shooting is due to the flinching of the firer caused by the heavy recoil, and the uncomfortable grip of the rifle, which militates against its being held firmly against the shoulder. With the revolving cannon, the less the force of recoil the greater the ease with which the handle of the gun can be revolved.

Assuming the energy of recoil of the Lee magazine gun to be fifteen pounds, and that fifty shots can be fired in the two and a half minutes, the fatigue to the shoulder and the muscles of the arm with the present weapons caused by such a fire would be exceedingly great, and we may very well doubt if any useful effect would be produced with the last ten or fifteen rounds fired.

With these facts before us, how necessary it is that we should very frequently have the actual conditions of battle practice, that we may be able, when called upon, to keep up an effectively aimed and rapid fire. Persistent effort is necessary in order to build up a body of seamen well skilled in the handling of small arms and rapid-firing cannon under battle conditions. Possibly a gunnery school established on shipboard at some convenient location on the Atlantic coast might supply the necessary want in this direction; when uniformity in our target

practice and drills would be attained, and one system, with no deviation therefrom permitted, strictly enforced on every ship in the service. In the establishment of a school of this character, it would be well to bear in mind that it is not necessary to demand too much from the seaman, such as filling his head with fine theories which he does not understand, and much less, never able to put into practice. Practical training must be the object sought when dealing with the seaman, in proof of which you have but to look at the navies of Europe to-day.

Here I would call attention to the following report, in awarding the Bailey Medal to one of the apprentices of the Training Squadron:

The Bailey Medal is awarded to —— ——, seaman apprentice, 2d class, serving on board the U. S. S. ——, 1887.

The following is a summary of the result of the examination of the contestant selected as best qualified on the ships of the Training Squadron, viz:

	Knotting and splicing.	Sail-making.	Heaving lead.	Heaving log.	Signals.	Exercise as captain of gun.	School of soldier.	Small-arm target firing.	Sword exercise.	Swimming.	Sewing.	Knowledge of his accounts with paymaster	Condition of clothing.	Total.
Maximum of marks in several subjects.	50	50	50	25	50	75	75	50	25	25	25	25	25	550
—— ——, seaman apprentice, 2d class, U. S. S. ——.....	38	24	47	20	45	70	60	17	21	24	20	13	22	421

Having adopted the magazine rifle for the seaman, we must give more care to our fire discipline and the expenditure of ammunition, particularly with landing parties. In order that the fire of the men may be controlled, magazines should not be used unless specially ordered. The detachable magazine of the Lee gun answers this purpose admirably; and in the instruction of the men, the piece would always need to be thrown to a perpendicular position opposite the left shoulder in order to attach the magazine. Officers' attention is thus attracted to the men in battle when loading, and the magazine fire kept in reserve for certain emergencies, and for the moral support which it would give to men who are aware that they have a reserve of fire constantly on hand, and a power to inflict sudden loss on an enemy at any critical moment of a fight *which no single loader can give.*

German and French authorities claim that the result of peace times with fairly drilled men must be ten times greater than those obtained in war; and assuming that the percentage of the wounded to the killed will be 7 to 1, it would be interesting to know what our men would do at the present time with small arms both afloat and ashore.

Captain Mayne, R. E., publishes some startling figures obtained from Prussian experiments, the same results having been obtained in Austria; that up to 770 yards the Prussian company column (250 men), lying down, will suffer, on an average at all ranges, two or three times as much as a company in line lying down; and that *the company column standing up* suffers but *little more loss than the company in line*, but beyond that distance its losses are more than double that of the line; that is, 770 yards in line 18 to 35 per cent, in company column 30 to 45 per cent, at 550 yards in line 30 to 60 per cent, in company column 40 to 65 per cent. It might be well to question these figures; but with a nation so practical as Germany in the instruction of her soldiers, it is doubtful if mistake in such experiments could occur.

The Italians say that the column suffers two or even three times as much as the line formation. At short ranges the difference is less, but at less than 550 yards the loss of men in column will be 50 per cent greater than that of men in line.* To continue this subject might divert us from the main issues of this paper; but it would be well to bear in mind in our musketry instruction and practice, that the results and figures obtained at these distances must be impressed on the minds of the men. They should also be impressed with the fact that, kneeling at 600 yards or more from an enemy, the losses inflicted would be less by one-half what they would be if standing, and if lying down the losses would be about one-fourth. Here the "Firing lying down position—Texas Grip," with the feet toward the enemy, as given in Captain Blunt's Rifle and Carbine Firing Instructions, appears to be best adapted for the protection of men from the enemy's shot. It also relieves the men's shoulders from the recoil of the piece, though not so easily taken as the prone position, which might be a consideration worthy of notice in the rapid advance of skirmishers. But no commander should be guilty of the mistake of allowing his men to lie down at short range, when advancing with an attacking force, more particularly if the force has met with much loss.

* This we very much doubt, for gaps must be filled in the line.

The Lee magazine gun, with the present detachable magazine, is not adapted for the use of blank cartridges, a defect that should be remedied; and in blank-cartridge practice with the rapid-firing guns, the experience on board H. B. M.'s ships Curlew and Black Prince, of the Channel Squadron, in the late naval manœuvres, August, 1887, in converting loaded into blank cartridges, ought to be remembered and avoided.

England proposes the adoption of an arm of calibre .307, and this fact, together with the reported experiments carried on lately in Germany and France with small calibre rifles, calibre .296 in the former country and .315 in the latter, if true, will cause a marked change in the small-arm armament of different countries. Greater range without raising back sight, thus doing away with the changing of sights at short ranges; weapons sighted with a full foresight; flat trajectories, which give a larger fire-swept zone; more rounds of ammunition, both as to weight and the number that can be carried in the magazine; slight recoil, and smokeless powder, will be the leading features of these new weapons. It is barely possible that a lighter rifle may be produced, as the question of rough usage in service will have to be considered. But we cannot help thinking that a test of the smaller calibres in battle will be the only means of ascertaining their superiority over the present arms, so far as the power to destroy life as well as to disable is concerned, which is the object of small-arm fire. It is claimed for the smaller calibres that they maim instead of kill, and that a wounded man requires others of the fighting force to care for him, while the killed need no care. In a great war that would demand all able-bodied men, women would have to care for the wounded, and the fighting force would not be decreased to any appreciable extent—in fact, in a navy, it would be a matter of no moment. A reduction in the calibres of small arms cannot follow the rapid advance made in that direction by heavy guns, the targets for the latter changing every day and at any moment of a fight, while those of the former always remain the same.

General Plan.—All men on shipboard, without exception, to be instructed in small-arm firings,—the word non-combatant should be stricken from our naval dictionary. At no time should a boat's crew be excused, be it barge or gig, nor should any one be excused connected with the engine-room force. Important or necessary work in the fire room or engine room can be carried on under an officer,

when the rest of the crew under an officer are cleaning ship in the morning or forenoon watches. If there is anything on shipboard that will cause discontent, it is the excusing of a class of men or a boat's crew from drill; and what can be more annoying to an intelligent and zealous drill officer, than to be called upon to excuse men while his drill is in progress? Every man in the Navigator's division stationed on deck should be instructed in the rapid-firing cannon, also the men belonging to the spar-deck guns, and the marine guard.

The officer in charge of each division should send to the commanding officer, through the executive officer, a written report of all men in his division excused from drill each day and for what purpose excused, the report to be forwarded to an inspection board. An equal division of the labor on shipboard for both officers and men, no matter how obtained, is the only road to efficiency and to a contented and well-drilled ship.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

THE V GUN SHIELD FOR CRUISERS.

By Chief Engineer N. B. Clark, U. S. N.

All the new cruising vessels yet designed by the Navy Department are to have the ammunition raised from the magazines to the deck by the old-fashioned shell whip hoists, and then transported along the open deck to the various guns, the crews of which are almost entirely unprotected; and this in the day when a storm of small missiles from machine gun, Hotchkiss, and rapid-fire shell guns makes life on the open deck utterly impossible, and when exposure, in combat with a protected adversary, is equivalent to death, and with it defeat and humiliation. The new offensive weapons by which the decks of warships can now be swept by storms of small percussion shell, which readily penetrate the sides of unarmored ships, imperatively demand and necessitate a change in the plan of mounting guns, and of the manner of conveying ammunition to them. It makes but little difference what the number and power of guns a ship may carry, if the crew cannot work them, or get ammunition to them, they will avail but little in a combat with a protected adversary; and protected the adversary can be, if he chooses, without increase of displacement, or abatement of speed or sea endurance.

The contest of the two British ships Shah and Amethyst, manned by highly disciplined crews, with the Peruvian monitor ram Huascar, "manned by a heterogeneous crew of undisciplined insurgents," would seem to prove that one ton of armored displacement was more than a match for eight tons of unarmored. It would therefore be better to have fewer guns well protected than a greater number unprotected.

The annexed illustrations are intended to show that the gunners of cruisers can be completely protected by appropriate armor while working the guns, and that the ammunition can be conveyed directly

to the breech of each gun through a vertical tube, or hollow shaft, by which the gun is trained, by means of a pneumatic engine situated in a passage leading to the magazine, below the water line, into which the vertical tube extends.

Fig. 1 represents a plan view of a section of the gun deck of a cruising vessel. The drawings are made to scale, and the guns represent the standard 6-inch rifle. The side of the ship has four feet tumble home, the guns and shields being mounted in little bay window-like projections, as shown in Figs. 1 and 2. The gun has no horizontal motion independent of the shield, and when the gun is trained to fire shot, the shield is also trained to deflect them coming from that direction. Attention is called to the very sharp deflecting angles at which the shield would receive shot coming from the direction in which the gun is trained, and also to the great range of fire which can be given broadside guns mounted in this manner.

Fig. 2 represents a cross section of a cruising vessel on the line *ij* of the plane view, Fig. 1. *A* is the curved shield for water line defense. Beneath this curved shield is a passage leading from the magazine, and extending along the ship's side under the broadside guns. *S* is a vertical tube, or hollow shaft, by which the gun and shield on the deck above are trained horizontally, and through which the ammunition is elevated into the shield near the breech of the gun. When the ammunition reaches the top of the vertical tube *S*, an appropriate guide causes it to fall over into the little truck *H*, which is held in position by a spring; one of the loaders, standing at the breech of the gun, then draws the truck out by means of a lanyard, and takes the ammunition from it, the truck being drawn back by the spring into position for another load.

Immediately over the gun, the upper portion of the broadside V shield is partitioned off by a cushioned platform *I*, on which the captain of the gun reclines in a prone position, aiming the gun through the sight hole *Z* in the apex of the V shield. This position over the gun would not be uncomfortable, as the concussion and vibrations of air producing sound are generated from the muzzle of the gun, from which the man would be well protected. This position, which is eminently adapted to the V shield, presents a less cross section of human anatomy than any other.

The shaft of the pneumatic engine *M* has cut upon it a worm screw, which engages in the gear wheel *N* secured to the lower end of the vertical hollow shaft, or tube *S*, and a lever controlling the valve gear

of the pneumatic engine is arranged convenient to the hand of the captain of the gun, so that he can train it with great rapidity and accuracy on any object, and hold it firmly in any position.

The broadside V shields are pivoted in the deck above at *W*, and on the deck below at the top of the vertical hollow shaft and conduit tube *S*.

The shield and gun are rotated on the anti-friction rollers *T* and *Q*, which are protected between two deflective plates, the upper one, *R*, being attached to the vertical hollow shaft *S*, and forming a part of the bottom of the shield, the lower one being attached to the deck.

Fig. 3 represents the plan view of a 10-inch rifle mounted *en barbette* on a V shield as a pivot gun, with all round fire.

Fig. 4 is a plan view of a loading lever by which it is proposed to convey the heavy ammunition of large guns from the upper end of conduit tube *S* (Fig. 5) to the breech of the gun.

Fig. 5 is a cross section of the V shield, Fig. 3, on the line *k,l*.

Fig. 6 is a plane view of *X* in Fig. 5, a device actuated by a spring for closing the opening between the gun and the shield when the gun is elevated.

Fig. 7 is a cross section on the line *m,n* of the vertical hollow shaft, or conduit tube *S*, which is given a deflective form.

In Fig. 5 *C* represents the loading lever, Fig. 4, which has two arms of unequal length, and is pivoted at the fulcrum between them. *E* represents a small truck, which traverses the long arm of the lever and is secured to it.

When the ammunition is pushed up through the vertical tube *S*, a guide causes it to fall over on the truck *E*, upon which, by means of a lanyard, it is drawn out to the end of the long arm of the lever, where it is held by a spring catch. Hydraulic or pneumatic power is then applied to the small oscillating cylinder *G*, the piston rod of which is attached to the short arm of the lever, thereby raising the ammunition on the long arm to the breech of the gun, as shown by the dotted lines in Fig. 5.

The pivot gun V shield is also trained by the pneumatic engine *M*, the lever for controlling the valve gear of which is marked *B*.

By means of the mechanical appliances described, two men can operate a very heavy gun, while there is ample room in the V shield represented by Fig. 5 for at least four men.

It is hardly necessary to state that the mechanical appliances herein described are not in any manner dependent on the principle of

deflection, as they can all be applied to an ordinary gun platform, either with or without any form of armor.

The deflective V shield was first brought to the attention of the Ordnance Bureau early in 1881, but received no consideration whatever.

The Naval Appropriation Act of 1882 contained a provision for the appointment of a Naval Advisory Board, to be composed of five naval officers and two civilians; the Act declaring "that no person shall be a member of said board who has any interest, direct or indirect, in any invention, device or process, patented or otherwise, to be used in the construction of the vessels."

The board was duly appointed, met, and gave each of the inventors presenting plans a hearing, and then on January 31, 1883, made a preliminary report to the Hon. Secretary of the Navy, in which they said: "The system of deflective decks submitted by P. A. Engineer N. B. Clark possesses great merits," and "the gun shields presented by Mr. Clark possess decided merits." It is understood such was the opinion of all the seven members of the board.

After making the preliminary report the board met again and adopted the gun carriage designed by the Chief of Ordnance, instead of the armored gun carriage or V gun shields which they had formerly reported upon as possessing "decided merits."

The objection made to the V shields is their weight. While the weight of the steam machinery of the Chicago is 419 pounds, and that of the Boston and Atlanta 448 pounds per I. H. P., the weight of the machinery proposed by me, having separate passage and emergency powers, would not have exceeded 150 pounds, thereby gaining sufficient weight to increase the power and speed, with great economy of fuel at passage speed, and to mount all the guns in invulnerable V shields, completely protecting the men, and avoiding the transportation of ammunition along the open deck, thereby giving the ships about eight times the fighting force they now possess.

Fig. 1.

Fig. 2.

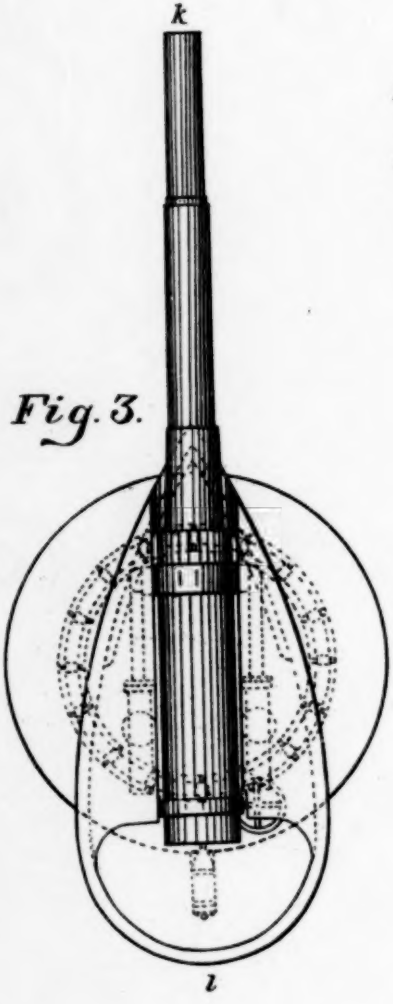
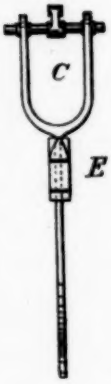


Fig. 3.

Fig. 4.



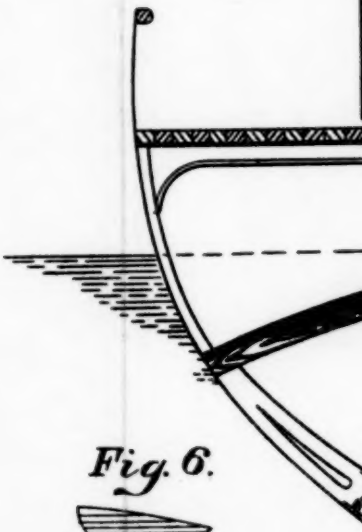


Fig. 6.

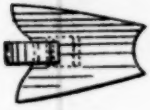


Fig. 5.

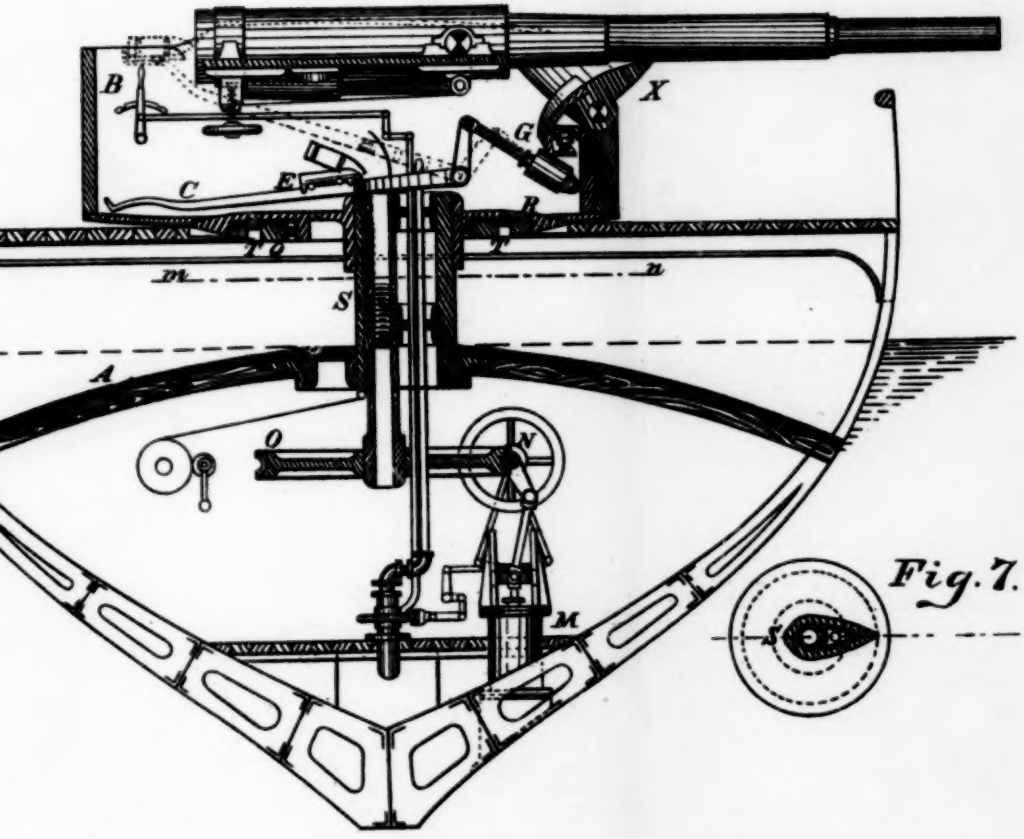


Fig. 7.

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THE SEPARATION OF THE PASSAGE AND EMERGENCY POWERS FOR WARSHIPS.

By Chief Engineer N. B. Clark, U. S. N.

A modern warship should have sufficient motive power to drive her at least 20 knots per hour in an emergency, such as chasing an enemy, or escaping from a superior force.

Her engines should also be designed so that while steaming from port to port they may function with the utmost economy at one-half that speed, at which she would consume, under ordinary circumstances, as much as 95 per cent of her fuel. As the sea endurance of the vessel depends so largely upon her economy of fuel at a low speed, the importance of the subject to a navy with few coaling stations needs no comment.

As the attainment of 20 knots per hour requires approximately eight times the power necessary to attain a speed of 10 knots, it will be readily understood that the two powers cannot be developed with equal economy in the same cylinders.

Soon after the organization of the Naval Advisory Board, under whose auspices the Chicago, Boston, Atlanta, and Dolphin were constructed, I submitted to that body the plan herein described, and urged it upon them as the type of motive power for the new ships.

Each vessel was to be fitted with twin screws, with two separate sets of engines on each screw shaft. The after engines were to be of a high grade of expansion proportioned to the development of the passage power, or about one-eighth of the whole power with which, with the utmost economy of fuel, a speed of 10 knots could be attained. The forward engines on each shaft were to be of a lower grade of expansion, in order to secure lightness of structure, and were to be proportioned for the development of the emergency power, which would be but seldom used. The screw shaft between

the two sets of engines was to be fitted with a clutch coupling, whereby the emergency power engine could be readily connected, or disconnected, as occasion required.

An alternative plan submitted was to connect both sets of engines to a counter-shaft, and gear them to the screw shaft with friction gearing. The latter plan presented the advantage of not transmitting the emergency power through the passage power cranks, and permitted any one of the four engines to be used for propelling the ship, in event of casualty to the others. Under ordinary circumstances the ship while cruising would be driven by her passage power machinery, thereby avoiding the loss incident to the development of a small power in a large engine.

I also proposed to the board that two different types of boiler be fitted in each ship. Steam for the passage power was to be generated in boilers of the ordinary durable cylindrical type; while the steam for the emergency power, which would be but seldom used, was to be generated in the far lighter, but less durable locomotive, or Herreshoff type.

By this means a great saving in the weight of machinery could have been attained; sufficient, in fact, to have fitted the vessels with invulnerable deflective V shields which would have completely protected the men working the guns, as well as the ammunition in its passage to the guns.

The Journal of the Franklin Institute, of Jan. and Feb. 1884, contained a description of my plan for warship machinery with separate passage and emergency powers, as submitted to the Advisory Board, and shortly after its publication the British Government adopted the plan of separate boilers in their new ships, and, according to Mr. F. C. Marshall, the armor-clad Sardegna, now building by the Italian Government, is to have the same principle applied to her engines, each screw shaft being fitted with two sets of engines, with a clutch coupling between them.

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U. S. NAVAL INSTITUTE, NEWPORT BRANCH.

OCTOBER, 1887.

NOTES ON THE LITERATURE OF EXPLOSIVES.*

BY CHARLES E. MUNROE.

No. XV.

"The Pneumatic Dynamite Torpedo Gun,"† which has been attracting so much attention for the past four years, is described and its good qualities set forth at length by E. L. Zalinski in the *Jour. Mil. Serv. Inst.* **8**, 1–35; 1887. The first 2-inch gun was designed and constructed by Mr. Mefford, of Ohio, in 1883; the 4-inch by Geo. F. Reynolds, and the 8-inch by Nat. W. Pratt. To Lieutenant Zalinski belongs the credit of having given direction to the development of this gun so as to render it a practical military appliance, by indicating in a general way the requirements to make it such, and he has labored most zealously to this end. The electrical fuze is alone his personal invention, but it is one of the most valuable and successful features of the system. The projectile used is a modification of a form designed by Colonel John Hamilton.

The 8-inch gun has been worked with 1000 pounds pressure, and at an elevation of 35°, a shell carrying 60 pounds of explosive has attained a range of 2¼ miles, while one carrying 100 pounds has attained 3000 yards with 33° elevation. The change in pressure during firing may be corrected by changing the elevation or the "cut off." Thus, in a recent trial, the initial pressure was 1000 pounds and the elevation 14° when, the "cut off" adjustment having been varied, the first round gave a loss of 47 pounds and a resulting

*As it is proposed to continue these Notes from time to time, authors, publishers, and manufacturers will do the writer a favor by sending him copies of their papers, publications, or trade circulars. *Address Torpedo Station, Newport, R. I.*

†Proc. Nav. Inst. **11**, 287–293; 767–769; 1885, and **12**, 617; 1886.

range of 1816 yards, while the second round gave a loss of 68 pounds and a resulting range of 2492 yards. Range tables for introducing both variables are to be provided the gunners on a brass plate attached to the pressure gauge.

Lieutenant Zalinski claims for this gun great rapidity of fire. He believes that with trained men the gun may be fired at the rate of once each minute. In the trial before a U. S. Naval Board, in June, 1886, with untrained men and without great effort being made, five rounds were fired in nine minutes and forty seconds. This was with the old form of projectile, involving the placement of the gas check, etc. The accuracy of fire in these five rounds was also remarkable. The range was 1613 yards, the elevation 10° 40′, the pressure 1000 pounds, and the "cut off" set to produce a loss of 50 pounds. Four of them attained exactly the same range, the other having gone only seven yards beyond. The maximum lateral dispersion was equivalent to only 6.2 yards. The wind was quite variable, but no attempt was made to follow it except once, just after the first round.

A 2-inch rifle gun has now been built which is to be tested, even to the final bursting of the gun, to establish the limits to which rifling can be safely used. A torpedo cruiser to carry two 10½-inch and one 12½-inch gun is now building for the U. S. Government. The range of these guns will be at least one mile. The 10½-inch shell will carry 200 pounds of explosive gelatine, equivalent, according to Zalinski, to 326 pounds of dry gun-cotton. The 12½-inch will carry 400 pounds of explosive gelatine, equivalent to 652 pounds of dry gun-cotton.

In comparing the pneumatic gun with gunpowder guns, Lieutenant Zalinski says: "The feasibility of using gunpowder for the propulsion of shell charged with high explosives is continually broached. It has been frequently tried, but invariably with final disastrous results, where the experiments have been carried up to moderately *large* charges.* By large charges, I refer to shell charges not less than fifty pounds and reaching up to one thousand pounds, and even to shell charged with a ton of high explosives.

"The advocates, or rather the predictors, of the use of high explosives from powder guns also demand *penetration* before explosion. If *large* charges are to be thrown, the shell must necessarily be made thinner, and it is very doubtful if it will then withstand the concentrated blow it receives upon striking the target, so as to penetrate even a moderate thickness of armor. The battering shell of the 100-ton gun

* Proc. Nav. Inst. **13**, 417; 1887.

contains a bursting charge of only twenty-five pounds of gunpowder. It would seem that the walls of the shell would have been made as thin as consistent with ability to perforate armor without breaking up.

"Assuming that twenty-five pounds of a high explosive could be substituted for the gunpowder, it is very doubtful if it could be carried through heavy armor successfully before explosion. There is no record of large battering shell fully charged with gunpowder having perforated armor over six inches in thickness, without explosion until perforation. On the contrary, explosion takes place prematurely, almost immediately upon impact, with the result of less injury to the target than that produced by an uncharged shell. Much more surely will this be the case if a high explosive be substituted for the gunpowder, as the bursting charge, unless the shell cavity is well cushioned. To do this involves reduction of explosive capacity. The energy available, after breaking up the very thick and tough walls of steel shell, will be but little greater than produced by the gunpowder. The effect as to the material injury or man-killing power will not much exceed that producible by the shell charged with gunpowder.

"In firing a shell from a powder gun, the walls of the shell must necessarily be sufficiently strong to withstand the initial shock. This limits somewhat the capacity for bursting charge, even when armor piercing is not sought for. If a high explosive is used, some cushioning device is requisite, and a further reduction of capacity ensues.

"Assuming that a shell charged with some of the high explosives can be thrown with safety from a powder gun under normal conditions of pressure, it is known that abnormal pressures, varying therefrom as much as 5000 to 12,000 pounds per square inch, are not infrequent. This may be looked for especially when the gun is warmed by continuous firing. In addition to this, the shell and the contained charge may become warmed by remaining in the hot gun bore some little time before being fired. The high explosives increase very rapidly in sensitiveness by slight increments of heat. If, then, with this condition of increased sensitiveness we have in addition an abnormal pressure, a premature explosion is very likely to occur. Much more will this be the case when the bursting charge is one of the high explosives. In this connection another matter is to be considered. It is well known that the high explosives are capable of producing more or less violent explosions, depending

upon the character of the initial shock or detonation. The more insensitive the explosive the more powerful must be the detonating charge to produce an explosion of the first order. Fulminate of mercury appears to be requisite in all cases. But fulminate of mercury is even more sensitive to shock than either ordinary dynamite or dry gun-cotton; hence the resulting shock must be tempered so as not to explode the more sensitive *detonating* charge rather than the specially insensitive *bursting* charge. Wet gun-cotton has been substituted for powder charges, but being quite wet reduces its explosive ability nearly to par with gunpowder. Particularly is this the case where no detonating charge is used of dry gun-cotton and fulminate of mercury. Where the explosion takes place by simple impact, not alone is it of a low order, but, as the initial point of explosion is from the front, the resulting injury to the target is less than from a blank shell." The author quotes Commander Folger, U. S. N., in support of these latter views.

In discussing the effect of tamping the author says: "A cartridge of 8 ounces of dynamite was suspended in superficial contact with an iron plate three-quarters of an inch thick and there exploded. The result was a simple indentation of the plate. A charge of 8 ounces was again suspended against the plate, but over it was loosely suspended a piece of angle iron open at both ends and of such size that the inscribed circle between its sides and the plate was less than the cross section of the charge, which was cylindrical. Thus there was no direct pressure against the cartridge, yet a large elliptical hole was blown through the plate considerably longer and broader than the cartridge. This experiment was repeated with almost identical results; when both plates were placed together a hole was blown through *both* plates."

Again: "Comparisons are frequently made as between the high-angle fire of the pneumatic gun and the flatter trajectory of high-power powder guns. The comparisons are persistently made, notwithstanding the fact that it should be considered more as a torpedo-projecting machine than as a gun, and that the comparison should be made with torpedoes rather than guns. Nevertheless, even when considered as a gun, its high-angle fire is not altogether a detriment, and possesses important elements of efficiency as such, even when compared with high-power guns.

The experiences at the bombardment of Alexandria, and practice trials from English ships under the most favorable conditions, indicate

that the great accuracy of fire of high-power guns is in a measure neutralized by the unstable platform which the ship gives. From this it would appear that naval combats, instead of taking place at ranges of from 5 to 10 miles, will rarely begin at much more than one mile range, and the tendency will be to come to closer quarters. Two miles may be considered the longest ranges at which attack of fortifications will take place." Hence, both "will be at such ranges as to make it possible to bring into play the pneumatic gun."

"The high-power guns, with their relatively flat trajectories, will be thrown out as to range, more by slight changes of angle due to the unstable platform, than will the higher angle fire of the pneumatic gun. The change of range due to error of judgment as to proper instant of firing will be much greater with the high-power guns than with the pneumatic gun. The variations of the latter are more likely to come within the limits of error in judgment of distances.

Again, at the short range mentioned, the high-power guns have, owing to the flatness of their trajectory, only the vertical projection of the sides and turrets of the ship as the available target, and missing these, no result can follow. This portion of the target is most heavily armored. On the other hand, the torpedoes from the pneumatic gun have, primarily, the over-water hull of the vessel, involving both its deck, which is relatively large in area and weak in armoring, and the vertical target to which the high-power guns are limited. To this last, if the calibre of the gun is moderately large, serious injury may be done, directly and indirectly, while the deck, if struck, is sure to be crushed in.

But, in addition to the over-water hull, it has the very great chance of doing fatal injury to the under-water hull, if missing the direct hit of the target.

No small element, in considering the effectiveness of this weapon, will doubtless be the moral effect. The knowledge that escape is not assured when the enemy's missile has failed to make a direct hit, and that the danger may even be *enhanced* by that miss, will not have a reassuring effect on the crew of the vessel attacked."

The writer then considers the use of this weapon for coast defense, countermining, for defense of ships, and as an adjunct for ships in ramming, and for torpedo rams. The paper is illustrated with a number of cuts.

By direction of the Secretary of the Navy, a test of the pneumatic gun was made September 20, 1887, by anchoring the Silliman (a

condemned coast-survey schooner, 80 feet long by 20 feet beam) at a distance of 1980 yards from Fort Lafayette, and using her as a target. The projectiles contained 55 pounds of explosive gelatine each, and three of them were sufficient to completely wreck the vessel. A description of the trial may be found in the *Army and Navy Journal* or the *Register* for September 24, 1887. Instantaneous photographs of the appearance of the target after each shot occur in the *Scientific American*, October, 1887. Some delay having arisen during the experiments with the Silliman, additional experiments for rapidity in firing were, according to the *Army and Navy Journal*, October 8, 1887, made September 30. Ten shots were fired, each projectile being loaded with 55 pounds of sand, and weighing complete 140 pounds. Firing commenced at 10.42 A. M. and ended at 10.52.30, or about one shot a minute. In the next shot the projectile contained 100 pounds of sand, and it weighed filled 203 pounds. With an elevation of 32°42′ it had a range of over two miles and a half. Time of flight 24½ seconds. Initial pressure of compressed air 975 pounds, final 825 pounds. Two similar projectiles, with an elevation of 15°, were fired with the gun sighted for 15 yards to left of target. The shots fell within 3 yards to left. The first projectile was 10 seconds in flight; initial pressure 750 pounds, final 625 pounds. The second was 9.04 seconds; initial pressure 750 pounds, final 615 pounds. Range 1772 yards. Of the time shell fired, two fell short 50 to 70 yards. Six would have hit a target the size of the Silliman, and two would have exploded sufficiently near to have injured her seriously. This was the first time that rapid firing with a large number of shell had been attempted, and the result indicated that a modification in the connections between the storage reservoirs and the gun was needed.

The experiments with this gun have given rise to considerable discussion. General Berdan gives his opinion of the value of the trial in the *Army and Navy Register*, October 8, 1887, to which Zalinski replies in the *New York Commercial Advertiser*, October 17, summarized in the *Army and Navy Register*, October 22. In the *New York Commercial Advertiser*, August 30, Zalinski also replies to the criticisms of General H. L. Abbot. In an interview in the *Washington Post*, October 16, Lieutenant John P. Finley, of the Signal Service, criticises the gun in the light of the dynamite experiments made at Sandy Hook, and points out how moisture on the hands or in the atmosphere may prematurely fire the electric fuze. The merits of the gun are strongly defended by Colonel John Hamilton, in the

Army and Naval Journal, October 29. This is but a minute part of the literature to which this invention has given rise.

Lieutenant C. A. L. Totten, U. S. A., proposes, in the *Army and Navy Journal*, July 23, 1887, that "Dynamite Archery" be resorted to, ships being armed with catapults, and *dynamite grenadiers* with crossbows from which arrows tipped with dynamite may be thrown.

Experiments in firing shells loaded with dynamite, by Mr. B. D. Stevens' method, were tried October 11, 1887, at the State Arsenal, Montpelier, Vt. The piece was a twelve-pound brass Napoleon; the shells were spherical, and the charge one-half pound of 35 per cent dynamite, a time fuze being used. The shells were fired with the usual service charge of two and a half pounds of powder. Five rounds were fired without any premature explosion. (*Army and Navy Register*, October 15; *Army and Navy Journal*, October 22, 1887.)

From the *Daily News*, Newport, R. I., October 24, 26 and 28, 1887, we learn that experiments have been made at the torpedo station to test the process proposed by Mr. Serge D. Smolianinoff for firing nitroglycerine with safety from gunpowder guns. His secret consists in rendering nitroglycerine perfectly insensitive to concussion or to detonation by heat, or by any means except by his patented burster. He further claims to be able to explode his shell at any point of the trajectory or after penetration.

The experiments consisted, after some preliminary trials, in firing shells filled with the mixture from service guns with two-pound charges of powder. Three filled shells, unfuzed, were fired at a stone wall forty-seven paces distant, without premature explosion. The remainder, fuzed, were fired up the bay. There was no premature explosion in the bore, and the shells exploded in mid air at a distance of about a mile, after about five seconds.

Mr. Smolianinoff had previously fired over 300 shells from a condemned 20-pound rifled Parrott, using an 8-inch conical shell completely filled with the prepared nitroglycerine, and a 3-pound charge of Dupont's F. F. powder, without having had a failure. The account of some of these earlier experiments will be found in the *Daily Alta*, San Francisco, Cal., June 13, 1887.

The *Illustrated Naval and Military Magazine*, **5**, 402–412, December, 1886, contains a quite interesting paper on the use of "High

Explosives in Warfare"; meaning thereby their use as charges for projectiles from guns. The paper opens with a lengthy description of the pneumatic gun.* This is followed by an account of the experiments made by the U. S. War Department† with explosive gelatine, and finally the experiments in Germany, Italy, Switzerland, and elsewhere with gun-cotton, hellhofite,‡ romite, Parone's explosive, and nitrocolle. The paper is liberally illustrated with cuts of apparatus and projectiles, and of fortifications and the like, showing the effect of the explosions.

It is stated that romite is a solid, containing neither nitroglycerine, gun-cotton, nor any analogous compound. It can only be exploded in a closed vessel by means of a dynamite cap, but this may occur at the lowest temperature. It can be manufactured without an extensive plant and at an extremely cheap rate. Romite was invented by Mr. Sjöberg, a Swedish engineer, and has been tested in shells by the Swedish artillery. The results were considered satisfactory, but only small amounts were used.

Parone's explosive consists of two parts of potassium chlorate and one of carbon disulphide. From experiments in Italy with the 9-cm. and 15-cm. projectiles it was concluded that this mixture was an exceedingly safe one; that it would not explode without a fuze—not always a desirable quality—and that although its effects were not strikingly superior to those of powder, they increased rapidly with an increase of calibre. On the strength of this report the explosive was fired from a 24-cm. mortar at a range of 3000 m. The mortar burst at the first discharge. The commission recommended the separation of the two constituents of the mixture, but this plan does not seem to have worked well.

Nitrocolle is, according to the *Belgique Militaire*, a new explosive discovered in Belgium, which is as powerful as nitroglycerine, but much easier and cheaper to manufacture. To make it, strong glue is placed in cold water until it has absorbed the maximum quantity of the latter; the mixture is next solidified by means of nitric acid, and afterwards treated with a mixture of nitric and sulphuric acids, as in the preparation of nitroglycerine. The resulting substance is finally washed several times to remove the excess of acid.

In summing up the results of the Italian experiments executed with the Gruson shell, the *Rivista d'Artiglieria e Genio* considers that

* Proc. Nav. Inst. **11**, 287; 1885. † Loc. cit. **13**, 411; 1887.
‡ Loc. cit. **11**, 771; 1885, and **13**, 240; 1887.

the Hellhoff's composition is a perfectly safe explosive, but that its power is by no means so great as had been expected.

In conclusion the writer says, although these experiments furnish few instances of full and complete success, we may infer that the future of high explosives is assured. It can now only be a question of time before the use of these agents in powder guns is rendered safe and effective.

An interesting series of experiments on Roburite* was carried out on June 14 at the School of Military Engineering, Chatham, under the superintendence of Major Sale, R. E. This explosive belongs to the Sprengel class, being a mixture of two substances, neither of which separately possesses explosive properties; in this case both components are solid, and the resulting mixture has a sandy, granular appearance, somewhat resembling the commonest yellow sugar. Roburite is the invention of Dr. Carl Roth, a German chemist, who claims for it the following advantages over other explosives:

1. That the two components are perfectly harmless and inert separately, so that they can be stored and transported without any restriction whatever.

2. That even when mixed or ground up together in ordinary coffee, cement, or flour mill, the mixture is perfectly safe to handle and use, as neither percussion, friction, nor the application of an ignited or heated body will cause it to explode; this can only be effected by using a detonator charged with fulminate of mercury.

3. That, when detonated, roburite produces neither spark nor flame, and will not therefore ignite either fire-damp or coal dust in mines. Dr. Roth states that this point was decided by the trials of the Imperial German Commission upon Accidents in Mines, and that in consequence this explosive is now being introduced into the coal mining regions of Germany, as affording absolute safety to the men employed.

4. The amount of noxious gases produced by its explosion is so infinitesimal that for this reason alone it is superior to other explosives in common use for deep mining work. The report from a mine in Westphalia, with shafts about 1500 feet deep, states with reference to roburite: "The men are not inconvenienced by the gases, and experience no difficulty whatever in breathing the moment after a shot has been fired, and they resume their labors at once."

* Proc. Nav. Inst. **13**, 420; 1887.

5. Roburite is not subject to deterioration through climatic variations of temperature. It should be kept dry, but if it becomes damp, its strength can be safely restored by drying.

The object of the trials was to test roburite in comparison with gun-cotton, dynamite and blasting gelatin. The programme of the experiments actually carried out was as follows:

A. Safety Tests.—After being ground through a small hand mill, the substance was struck direct and glancing blows with heavy hammers upon iron plates, without any result. Flame was then applied to a portion of it by means of a short length of Bickford fuze, but without igniting the mass; thrusting a red hot iron from a portable forge into the roburite caused only slow combustion and crepitation locally, which ceased when the iron was withdrawn. When a quantity was put on the forge fire it merely burned away like an ordinary combustible. Dr. Roth wished to fire a powder charge in contact with the roburite, but it was considered that the above named tests were more severe.

B. Tests on mild steel plates 2 ft. 6 in. by 2 ft. 6 in. and of various thicknesses. These plates were laid flat in shallow trenches, a hollow being left underneath the central portion of each plate; heavy timber balks were stacked around each square trench, with the object of showing the comparative dispersive force of each explosive.

1. Three pounds each of dynamite and roburite were placed on the centre of plates 2 in. thick, some sandy loam being piled loosely on top. The results of detonation were that the dynamite produced a dent in centre of plate 1¾ in. deep; the indentation produced by the roburite was about 1½ in. deep, but the bulge appeared to have a wider area than in the former case.

2. Five pounds each of roburite and gun-cotton were then exploded upon the same plates, with the result that, in the former case, the plate was smashed into four tolerably equal pieces, while the gun-cotton made a breach through the centre of the plate somewhat resembling that which would be caused by the penetration of a large projectile. The diameter of the hole was roughly 12 in., with five radial fissures almost reaching the edges, the longest 15 in., the plate being at the same time bent into the shape of a pack saddle; this would seem to have been a remarkably tough piece of metal. The timber balks were scattered in all directions.

3. Eight pounds each of dynamite and roburite were then detonated upon plates 3 in. thick. The dynamite caused an indentation

2¼ in. in maximum depth, while the roburite gave a bulge 3 in. deep in the centre, and of a larger area, reaching apparently almost to the corners of the plate.

4. This series of tests was concluded by exploding 12 pounds each of roburite and gun-cotton on plates 4 in. thick, rather more loam being heaped on top of each. The roburite caused a wide indentation 1⅞ in. deep in centre, while the tremendous local force of the gun-cotton was exemplified in a striking manner. In addition to an indentation 3½ in. in greatest depth, a small crack appeared to extend right through the plate, this crack corresponding with one edge of the lowest slab of gun-cotton, the rectangular shape of which could be clearly seen indented on the steel plate, the depth being ¼ in. at the crack and ⅛ in. along the other edges of the slab. There is a circular hole drilled in the slab of wet gun-cotton to receive a small cylindrical disk of dry gun-cotton as a primer, and the position of this disk was marked by a circular hollow in the steel plate ½ in. deep in centre.

C. Blasting or Mining Test in Brick-work.—Three holes, each 1¼ in. in diameter and 18 in. in horizontal depth, were drilled in the solid brick-work of the counterscarp wall, and were respectively charged with 2 oz. of gun-cotton, blasting gelatin, and roburite; the holes were then tempered with loam in the ordinary manner, and fired by means of short lengths of Bickford fuze. The gun-cotton produced no apparent effect upon the brick-work, but Major Sale was of the opinion that the hole must have been open, or very weak, at the back. The blasting gelatin produced violent local action, displacing the brick through which the hole had been bored and the four adjacent to it. There was a slight bulge in the wall, the cracks extending radially from 10 in. to 12 in. The roburite exhibited a more widespread rending action upon the wall, the radius of disturbance being 15 in. or more, and the bulge being also greater. Rather larger charges of each explosive would have afforded a more satisfactory comparison.

D. Ground Mines.—Ten pounds each of gun-cotton, blasting gelatin, and roburite were loaded into holes in the bottom of the ditch 4 ft. deep by 8 in. in diameter, filled up with sand and slightly tamped. The explosion of these charges cast up tremendous fountains of loam and sand, and resulted in the following craters: Gun-cotton, 10 ft. 6 in. wide by 1 ft. 8½ in. deep; gelatin, 14 ft. 6 in. wide by 3 ft. 7 in. deep; roburite, 12 ft. 3 in. wide by 2 ft. 9 in. deep. The explosion of the gun-cotton mine appeared to cause great local action; but it will be

seen that the area and depth of its crater were considerably less than that caused by the roburite, which again must yield the palm in this instance to the blasting gelatin. It is, however, to be remarked that these mines had been placed much too close to one another, so that their craters crossed; this would give whatever charge was the last to explode a certain advantage.

In summing up the results of the foregoing experiments we must bear in mind the great difficulty—we had almost said the impossibility—of obtaining any absolute standard of comparison of the relative strengths of two or more explosives. Each will seem to prove itself superior for certain purposes. Judged, however, by any standard of comparison, it appears that the new explosive has acquitted itself very well, and, especially when we consider its absolute safety, must have a great future before it. Roburite has shown itself to be in some respects more powerful than dynamite, to which it is likely to prove a serious rival in the industrial field, although the latter has the proverbial advantage of strong possession of the ground. An important element in the struggle for ascendency will be the price at which roburite can be supplied as compared with dynamite, and this will be, we understand, strongly in favor of the new substance.

As regards the military application of explosives, there is nothing in the results of these trials to disturb the firm conviction of our Government that gun-cotton is the best adapted for torpedo charges, submarine mining, and hasty demolitions of all kinds. Its superiority in local force to dynamite, when employed without any confinement, is once more strikingly demonstrated, to say nothing of the far greater safety of wet cotton and its applicability for use under water with no other confinement than that of a net to keep the slabs together. But although quite outside the scope of Tuesday's experiments, the great power and perfect safety of roburite seem eminently to fit it for use as a bursting charge for shells, into which its granular form would allow it to be conveniently loaded. Much stronger than any picric powder, and doubtless better able to withstand the concussion of the discharge of the gun, an extended series of trials would be necessary to determine the best mode of so employing it. (*Engineering*, 43, 573, 574, June 17, 1887.)

The *Army and Navy Journal*, October 1, 1887, quoting from the *London Times*, gives the name of the reported new Russian explosive *

* Proc. Nav. Inst. 13, 248; 1887.

as Sleetover, and states that it is equal in strength to pyroxyline, and very cheap. "Another great superiority which it possesses over all the known explosives of the dynamite class is that when fired its force does not strike downward, but entirely in a forward direction, so that it can be used for all the purposes of cannon and musket charges to which ordinary gunpowder is now applied, without any damage whatever to the weapon from which it is discharged. It is stated, in fact, that ball cartridges loaded with it have been fired out of card-board barrels, as a test, without the least injury to the latter."

The "new Swedish explosive," bellite,* discovered by Mr. Carl Lamm, director of the Rötebro Explosive Manufactory, Limited, near Stockholm, consists of ammonium nitrate and dinitro benzene, which, when in a melted condition (the melting point is 80° to 90° C.), are mixed with saltpetre, forming a compound of which each molecule explodes. Bellite, when pressed warm, has a specific gravity of 1.2 to 1.4 in its granulated state, which, according to the experiments already made, seems to be the one best suited for military purposes. One litre of bellite weighs 800 to 875 grams.

Heated in an open vessel bellite loses its consistency at 90° C., but does not begin to separate before a temperature of 200° C. is reached; at that point evaporation begins, and increases with a higher temperature, without, however, explosion occurring. If the heating is sudden, bellite will burn with a sooty flame, something like tar; but if the source of the heat is removed, the bellite will cease burning and assume a caramel-like structure, the ingredients being the same as in its original state, with the exception of a somewhat reduced proportion of saltpetre. The explosive appears to absorb little moisture from the air after it has been pressed; if this operation is performed in the hot state, the subsequent increase of weight is only 2 per cent.

From the experiments of Werner Cronquist and Professor Cleve we learn that when bellite is subjected to the most powerful blow a man is capable of inflicting with a steel hammer upon an iron plate, it becomes heated, but neither explodes nor ignites. Two grains of bellite in a blank copper cartridge (that of a Remington rifle) were placed on an iron plate and subjected to the fall of a weight of 200 pounds from a height of 17 feet 6 inches, without exploding. Layers of bellite .47 inch in thickness on wood or iron have been pierced with rifle balls fired at a distance of some 50 yards, without showing

* Proc. Nav. Inst. 13, 247–248; 1887.

signs of exploding or ignition. While boring in cast iron with a steel drill, one grain of bellite has been placed in the hole, neither explosion nor ignition having resulted, although no sort of oil or other lubricator was used. A small quantity was fixed to the pointed end of a steel rod, and the rod knocked so hard against quartz as to produce sparks, yet there was no explosion. A good sized piece of bellite was placed in an open tin box and covered with gunpowder, the latter was ignited, the explosion throwing the bellite several yards in the air, but it did not explode. In a piece of hard wood a hole was made of the size of a penholder, two grains of bellite were pressed hard into the hole and this closed with a wooden cork. The wood was thrown into a coke fire and consumed, but there was no explosion. A compressed bellite cartridge was placed close to a rocky wall, and some three inches from it a cartridge of nitrolite (nitroglycerine, gun-cotton and nitrate of ammonia); the latter charge was made to explode by a Stubine percussion cap, and after the explosion the bellite cartridge was found to have been crushed, and the powder into which it was turned was fixed to the rock. The bellite had consequently not exploded. The list of these experiments might be considerably increased, but sufficient has been said to prove that bellite can withstand blows, fire, friction, and vibration, without the slightest risk of explosion. It can be safely transported by rail, and stored without any danger of spontaneous combustion.

Granulated bellite is caused to fully explode by the aid of a small quantity of fulminating mercury, even if its cover only consists of thin tin. When pressed warm, especially when it is in the form of hard cakes, it requires a stronger impulse and a stronger cover, which must adhere to the bellite.

The suitability of bellite as an explosive for grenades (when these are provided with a proper percussion tube) has been established through a series of experiments carried out by officers of the Swedish Royal Artillery. A series of experiments has been made by exploding under water, mines loaded with bellite against a dynamometer. The average of several explosions gives, at a distance of 17 ft. 6 in., a blow of equal power to that caused by a weight of 22 pounds falling from a height of 39 in. At a reduced distance of 12 ft. 6 in. the effect was proportionately increased. On comparing the efficiency of bellite with that of gun-cotton, under exactly similar circumstances, the former shows a superiority of 10.4 per cent at a distance of 17 ft. 6 in., and of 15.2 per cent at a distance of 12 ft. 6 in. The firing of 25-

millimetre machine-gun ammunition and steel bullets against mines loaded with bellite had not the least effect upon the explosive, thus proving it to possess a great advantage in this respect over other explosives generally used for submarine mines.

It is the opinion of those who have had the best opportunities of judging, and whose verdict is of acknowledged authority, that bellite bids fair to become of great importance; that it is equally suitable for mining and military purposes, while it is not so liable to be put to an undesirable use as are most other powerful explosives. (*Engineering*, 44, 18, July 1, 1887.)

The press reports that an accidental explosion of melinite occurred at the arsenal at Belfort, March 10, 1887, by which six men were killed and eleven wounded. The *Army and Navy Journal*, May 14, states that in spite of this accident, and of a more recent one at Bourges, the belief in the new explosive is not abandoned, and that shells filled with it are to be tried against the Belligueuse, one of the early iron-clads, of 3617 tons displacement. The Germans, however, claim to have proved by experiment that melinite decomposes if kept long, and is therefore useless for war purposes.

U. S. Letters Patent No. 350048, September 28, 1886, have been granted to Eugene Dupont for a gunpowder press, in which two hydraulic rams, furnished with pins, work through each face of the mold plate. The result of this operation is that the powder in the apertures of the mold plate is compressed with equal force at both ends, and large grains of the desired dimensions and form (cylindrical or prismatic) are produced, in which the ends of the grains, being compressed with equally-moving pistons or rams, are both hard, while the central parts of the grains are comparatively soft when the grains are removed from the molding apertures. A grain of such construction, having two hard ends and a comparatively soft centre, is of great advantage in firing large ordnance, as it burns with great rapidity from the centre as well as the ends when once started, though the initial rate of combustion is slow, owing to the compacted ends. What he claims is—

In a machine for forming grains of explosive compounds, the combination of a fixed mold plate containing suitably formed apertures for molding powder; two equally-moving and balanced rams acting to compress the grains from both ends, and pins passing through the

apertures in said mold plate and having a longitudinal motion therein independently of said rams, substantially as and for the purposes described.

U. S. Letters Patent No. 352611, November 16, 1886, have been granted Eugene Dupont for an explosive compound, in accordance with the following specification:

My invention consists in the use, in explosive compounds, of wood slightly changed in its chemical formula by the application of heat for the two purposes of increasing the ballistic force of the powder and of controlling the rate of combustion so as to adapt it for use in heavy charges behind projectiles of great weight, or to lighter charges in medium sized guns. With this end in view, I replace (either wholly or partially, as desired), the charcoal which is used in the composition of ordinary gunpowder, with the requisite amount of wood slightly changed in its chemical formula by having been subjected to heat or baked, as hereinafter described.

I have found that branch-willow wood is well adapted to the purpose; but any suitable wood for making gunpowder charcoal may be used.

I subject the wood to a gentle heat (either in a retort over a slow fire, or by the application of superheated steam in a suitable vessel), gradually raising the temperature to about 450° Fahrenheit, at which the heat is maintained for about two hours (this would be for three-fourths of a cord of willow), the entire time consumed in the baking being about eight hours, six hours being consumed in obtaining the proper temperature. The limits of temperature at which the baking should cease (as far as I am now aware) to secure good results are 300° Fahrenheit and 450° Fahrenheit, the lower temperature making the wood less rapidly combustible, and the higher securing a more combustible wood. The process of heating the wood, as described, should cease before the wood is transformed into red charcoal, which is useless for my purpose, as red charcoal has entirely lost the fibrous character of the wood, while in the wood which I use in the present invention the fibre is still undestroyed; and it is by breaking the wood and examining if the fibre has been destroyed that I am able to determine the point at which the baking should cease. 450° Fahrenheit is a temperature high enough to transform the wood into red charcoal, if maintained for a length of time; but I remove the wood before such transformation takes place.

My baked wood differs from red charcoal not only in its physical character by retaining its fibre, but also in its chemical formula. Red charcoal is considered to contain about 72.64 per cent of carbon, 4.71 per cent of hydrogen, 20.08 per cent of oxygen, and 0.57 per cent of ash. Although not a definite chemical compound, but being produced by partial decomposition, it will vary slightly in its formula. This also applies to my baked wood, which may vary even more than from 47.51 per cent of carbon, 6.12 per cent of hydrogen, 4.29 per cent of oxygen, and 0.08 per cent of ash, to 51.82 per cent of carbon, 3.99 per cent of hydrogen, 43.94 per cent of oxygen, and 0.22 per cent of ash; but, as will be seen, it has much less carbon than red charcoal, and still less than black charcoal. The carbon in my baked wood also retains to a certain extent, after being ground fine, its cellular form, and combines with the liberated oxygen from the saltpetre more readily than other forms of carbon, for instance, stone coal or lamp black.

The greater proportion of the oxygen and hydrogen in my baked wood than in charcoal is of very great importance to the ballistic effect of the powder. The theory of their action, as proved by experiment, is as follows: The temperature, after ignition of the charge in the gun, reaches 4000° Fahrenheit, a degree of heat too high to permit the oxygen and hydrogen to combine to form water, and they therefore must remain uncombined until, by the expansion due to the motion of the projectile toward the muzzle, these gases are cooled sufficiently to permit their union. When this takes place, a very large amount of heat is disengaged, which expands again the steam and other gases formed by the combustion of the powder. The pressure thus sustained while the projectile is in the gun insures a high velocity and a low pressure, because all the atoms of the powder cannot form new combinations at the time of ignition, but part of them unite as the pressure falls. It is therefore important to get as much of the substances containing oxygen and hydrogen in proportions to form water, or approximate proportions, into the powder as possible, and I therefore prefer the baked wood, which contains these gases in such proportions, besides having its carbon, as stated, in a form to unite readily with oxygen. The fibrous character of my baked wood also gives toughness to the grains of powder and prevents the grain from breaking up too rapidly.

It is unnecessary to describe the method of combining the components of powder, for that is well known, but I have found the following

ingredients and proportions to form a desirable powder for guns of twelve-inch calibre: saltpetre, seventy-eight parts, by weight; sulphur, three parts; baked wood, 12.5 parts; ordinary wood pulp, 2.5 parts; sugar (the use of which forms the subject of my application for letters patent, filed August 12, 1885, No. 174214), four parts; or, as I have also found the wood pulp may be omitted, as the grain will be toughened by the fibre of the baked wood, the proportions in this case being about as follows: saltpetre, 78.95 parts, by weight; sulphur, three parts; baked wood, 15.02 parts; sugar, 3.03 parts.

I do not limit myself to the special ingredients or proportions given above, as my invention consists in the combination of baked wood, as herein described, with well known gunpowder ingredients, and other equivalent ingredients may be substituted for those above mentioned.

What I claim is—

An explosive compound consisting of a nitrate and sulphur combined with charcoal retaining its fibrous structure, substantially as described.

In U. S. Letters Patent No. 363887, dated May 31, 1887, Eugene Dupont claims to have invented a new and useful compound, principally for use in guns of medium and large calibre, of which the following is a specification:

The first object of my invention is to obtain an explosive which shall have great ballistic force; and its second object is to obtain a powder which shall obviate, as far as possible, the many disadvantages pertaining in a greater or less degree to all artillery explosives, and which consists in the smoke arising from the burning powder, such smoke obscuring the view and interfering with the sighting for a second shot.

I have found by experiment that substances having in their component parts the elements of hydrogen and oxygen in such proportions that, upon being released from the rest of the component parts by combustion, they will combine to form water and steam, and greatly increase the explosive force of the powder of which they form a constituent element. The action of such powders seems to be as follows: Upon firing the charge, the gases confined in the powder are released, and act to expel by their expansion the projectile toward the muzzle of the gun. This I term the "first explosion." At this time the oxygen and hydrogen are released as gases, but under too

great heat to unite in the form of steam. As the pressure is decreased by the motion of the projectile in the gun, this heat also decreases, and the gases—oxygen and hydrogen—unite in the form of water. The heat generated by this union at once changes the water into steam, and this expansion, which takes place before the projectile leaves the muzzle of the gun, I term the "second explosion." There is thus formed a powder of great explosive force, which acts twice upon the projectile. I have also found that such powders are very effective in dissipating the smoke arising from the discharge, owing, as I suppose, to the fact that the steam, generated as above stated, condenses, and in so doing absorbs large quantities of the carbonate of potash, the solid portion of the result of decomposition of a charge of powder and that portion which forms the smoke.

Thus I employ in place of the carbon usually used in the composition of explosive powders, the substances known as "carbohydrates," and which have the chemical formula of cellulose, $C_6H_{10}O_5$, or an approach to it, such as wood pulp, starch, dextrine, etc., or other substances, such as sugar, having substantially the chemical formula of $C_{12}H_{22}O_{11}$. All such substances having substantially the formulas aforesaid, and the capacity of forming water and steam by the action of the explosion, I term in this specification "carbohydrates." Instead of using one substance having the required chemical formula, two or more may be used having the necessary elements separate, which, when liberated, will combine to form steam and act in the manner required.

The materials should be mixed in a finely divided condition, and it is better to mix the carbohydrates with the other ingredients of the powder after such other ingredients have been mixed, as such carbohydrates are apt to be gummy in their nature.

I have found, for example, that a very effective powder may be made of the following substances, in substantially the proportions specified, viz., saltpetre (for which other known nitrates may be substituted) 78 parts, sulphur 2.8 to 3 parts, carbohydrates 3 to 4 parts, charcoal retaining its fibrous structure 12 or 12.5 parts. This powder, to be most effective, should be made in prismatic grains, and I have found that the best results are obtained by so constructing said grains that they are less dense in the middle than at the ends, which therefore have the particles more compacted together at those points than in the middle. My method of making these grains of such varying density is described in an application for letters patent,

filed August 12, 1885, Serial No. 167749. Such form and construction of the grains retard the development of the gases from combustion, until it is desired to obtain the maximum force; and I find that the fibres of the charcoal, retaining its fibrous structure referred to, materially aid in this result, as they tend to prevent the grains of powder from becoming broken up. The use of charcoal retaining its fibrous structure, as above referred to, forms the subject of an application for letters patent, filed June 5, 1885, Serial No. 167748.

What I claim is: 1. An explosive compound consisting of a nitrate, sulphur, charcoal retaining its fibrous structure, and a carbohydrate, substantially as described.

2. An explosive compound consisting of saltpetre, sulphur, charcoal retaining its fibrous structure, and sugar, substantially in the proportions specified.

From *Ding. Poly. Journal*, **263**, 149; 1887, we learn that the composition of the brown prismatic powder sometimes known as cocoa powder is yet a secret, but it has been suggested that the charcoal used in its manufacture is made from peat, and the mysterious actions of the inventor tend to confirm this opinion. It is stated also that charcoal for this purpose is made at Chilworth and elsewhere by the action of superheated steam on rye straw.

We have frequently been asked to state to what the properties which distinguish the brown prismatic powder are due, and we trust it may not be considered out of place if we state our theory in this connection.

We hold that its property of imparting a high initial velocity to the projectile, while only exerting a relatively low pressure on the walls of the gun, is due to the combined action of a number of causes, viz:

1. The form of the grain; 2. the size of the grain; 3. the great density of the grain; 4. the great hardness of the grain; 5. the small percentage of sulphur; 6. the easy inflammability of the charcoal or carbohydrates; 7. the relatively great heat evolved; 8. the simplicity of the chemical reaction.

Cause 5 tends to reduce the readiness with which the powder will ignite, or raises its point of ignition, even when the grain is pulverized. Causes 1, 2, 3, 4, and 5 combined operate, so long as the first four exist, to produce a very slow rate of combustion. By the time, however, that the projectile is moved from its seat, the grains will be

reduced in size and more or less broken up. We shall then have a fine-grained powder which is highly inflammable at the temperature which exists (cause 6), and consequently the volume of gas evolved will increase rapidly as the volume of the chamber increases. Owing to the relatively great quantity of heat evolved (cause 7), the cooling effect of the envelope is less marked than with other powders. As the chemical reaction is a comparatively simple one (cause 8), the speed of the reaction is probably more uniform than when the reaction is more complex, as in other powders.

According to Berthelot, dissociation plays an important part. This is possible, and even probable, with powders made from underburnt charcoal, as this contains carbohydrates, or with those in which the carbohydrates are a constituent of the mixture.

The advantage of the form of grain employed was pointed out by Rodman,* the inventor, and his views have been confirmed by Sarrau.† The advantages of size, density (this is 1.86 in cocoa), and hardness are commonly known. Berthelot and Vieille‡ have shown that the hydrates of carbon, such as cellulose, contain an excess of energy above that given by the carbon and water which their decomposition would furnish. And Noble states,§ in his lecture on the "Heat-Action of Explosives," that a unit mass of cocoa powder yielded a greater number of units of heat than any other of the standard powders, which Abel and Noble tested, yielded. He also shows‖ that the chemical reaction attending the combustion of cocoa powder is simpler than that attending any other.

U. S. Letters Patent No. 362899, May 10, 1887, have been granted to Thorsten Nordenfelt, of Westminster, England, and Victor A. Meurling, of Christianstad, Sweden, in accordance with the following specification:

At the present time, in the manufacture of gunpowder, it is usual to incorporate the sulphur and saltpetre with the other materials by a process of grinding. This grinding is a dangerous operation after the saltpetre is added, and it has to be long continued in order that the mixture of the materials may be sufficiently intimate. Now, in place

* Experiments on Metals for Cannon and Cannon Powder, 291–297; Boston, 1861.

† Proc. Nav. Inst. **10**, 160; 1884.

‡ Proc. Nav. Inst. **12**, 187; 1886.

§ Heat in its Mechanical Applications, Inst. Civ. Eng. Lond., 211; 1885.

‖ Loc. cit. 209.

of thus producing a mechanical intermixture, which, after all, can only result in placing minute particles of sulphur, saltpetre and charcoal side by side, we bring the sulphur to a state of solution in bisulphide of carbon, and in this state we combine it with suitable carbonaceous matter. In this manner we diminish risk in manufacture, we manufacture the powder more cheaply, and obtain a powder which is more even in its results.

If it be deemed desirable to use wood charcoal, it may be employed as the carbonaceous matter in the manufacture of the gunpowder in carrying out our invention; but as we have found cotton or wood fibre or other like vegetable fibre reduced to a state of fine powder by a chemical process a preferable carbonaceous matter, we employ it. The vegetable fibre, whether it be cotton or wood fibre such as is used in paper making, or other vegetable fibre, is placed in a loose state in a vessel through which a current of hydrochloric gas is caused to pass so that it may permeate the fibre. After a time the fibre will be found in a friable state, such that it may easily be reduced to powder by friction. The current of hydrochloric gas is then stopped, and is replaced by a current of air, which is continued until the gas is thoroughly expelled.

The following is the manner in which we conduct the manufacture of gunpowder: The ingredients are sulphur, saltpetre, and the carbonaceous matter. The materials should be pure, and the proportions the same as now used in gunpowder, subject to variation to some extent, and, as is now usual, to adapt the powder to the various purposes for which it is required.

We first grind the carbonaceous matter to a very fine powder, the finer the better. We prepare the sulphur for use by dissolving it in bisulphide of carbon. The solution is effected by the aid of a gentle heat in a water-bath, and the evaporation of the bisulphide may be prevented by covering its surface with a layer of water. A saturated or nearly saturated solution should be thus prepared. The pulverized carbonaceous matter and the solution of sulphur in bisulphide of carbon are then thoroughly mixed together in a closed vessel containing a mechanical stirrer. When the mixture is complete, the solvent is evaporated or distilled off by the aid of a gentle heat. The vapor of the bisulphide is collected and condensed, so that the solvent may not be lost. The means for this purpose may be such as are employed when this liquid is used in the preparation of extracts and for like purposes. When the bisulphide of carbon is evaporated, the

carbonaceous matter and sulphur remain intimately mixed, and each particle of carbonaceous matter has become impregnated with sulphur, instead of as at present, where the admixture is obtained by grinding, the particles of carbonaceous matter and sulphur being only mechanically placed side by side. The saltpetre is prepared for use by dissolving it in water, the solution is added to the pulverized carbonaceous matter already impregnated with sulphur as described above, and the whole is stirred together in a mechanical mixer.

We find it advisable not to add the whole of the saltpetre at one time, but to divide it into two or three separate quantities, and with each quantity we have sufficient water to render it sufficiently fluid for impregnating the carbonaceous matter already impregnated with sulphur.

After each admixture the water is separated by evaporation, and heat may be applied to hasten this evaporation, but in such manner as to avoid risk of the materials igniting as they become dry. After the first drying operation the material, in a state of powder, is again mixed with saltpetre solution, and it is afterwards again dried as before, and so for three or more times, should it be considered desirable to divide the operation of incorporating the saltpetre into so many operations. When the incorporation of the saltpetre is complete, it only remains to finish the powder for use by ordinary methods. It may be compressed into cakes or prisms, dried, broken up, and granulated in the usual manner.

By this method the dangerous process of grinding the powder after it has been rendered explosive by the addition of the saltpetre may be altogether avoided; or if in any case it should be considered advisable to resort to a grinding process after the materials have been mixed in the manner above described, the danger would be much less than at present, because of the lessened time during which the grinding would be continued.

The carbonaceous matter may also be submitted without risk to a grinding operation after the sulphur has been incorporated with it and before the saltpetre is added.

Although our invention is mainly intended for the manufacture of gunpowder from the ordinary ingredients, it is also applicable to the manufacture of like compounds in which the saltpetre is replaced by nitrate of soda or other salt capable of furnishing the oxygen to the carbonaceous matter and sulphur.

In the preparation of the cotton or vegetable fibre, liquid hydrochloric

acid may be employed; but the use of the gas, as herein described, is preferable.

Having thus particularly described and ascertained the nature of our said invention and the manner of performing the same, we declare that what we claim is—

1. As an improvement in the manufacture of gunpowder, the method described of incorporating the sulphur with carbonaceous matter, which consists in dissolving the sulphur in bisulphide of carbon, impregnating the carbonaceous matter with the solution so obtained, and separating the bisulphide of carbon by evaporation, substantially as set forth.

2. As an improvement in the manufacture of gunpowder, the method described of incorporating the sulphur and saltpetre or equivalent salt in the carbonaceous matter, which consists in dissolving the sulphur in bisulphide of carbon, impregnating the carbonaceous matter with the solution so obtained, separating the solvent by evaporating; also impregnating the carbonaceous matter with saltpetre or equivalent salt in solution, and separating the solvent by evaporation, substantially as set forth.

3. The hereinbefore described method of manufacturing gunpowder, which consists in treating cotton or equivalent vegetable fibre with hydrochloric acid (either gaseous or liquid) to obtain carbonaceous matter* with the sulphur and saltpetre, substantially as set forth.

From *Rept. H. M. Insp. Exp.*, p. 44; 1885, we learn that an explosion took place in a factory in which gunpowder was being made by Mr. Nordenfeldt's process. The accident was wholly due to carelessness, but the inspectors found that the presence of bisulphide of carbon in powder tends to sensibly lower the point of ignition.

U. S. Letters Patent No. 359289, March 15, 1887, have been granted to Edward Schultze, of Darmstadt, Germany, in accordance with the following specification:

The improvements in the manufacture of gunpowder and similar explosives consist in the composition and combination of three kinds of materials—of a nitro-hydrocarburet with pyroxyline, and thirdly, with a nitrate or salt, formed by the union of nitric acid with a base, and furnishing a compound of oxygen and nitrogen. By mixing these three constituents in various proportions I am able to produce

* Proc. Nav. Inst. 8, 309; 1882.

an explosive of greater or less force. When this mixture is to be used as gunpowder for shooting purposes, I take a certain amount of the pyroxyline and diminish the rending force of the pyroxyline by adding nitro-hydrocarburets and nitrates; but when I wish to use said mixture as a blasting explosive, for blasting hard rocks or minerals and other blasting purposes, I augment this amount of pyroxyline with a view to producing greater rending force. When burning, these mixtures are free, or nearly, from noxious fumes, residue, and recoil. I instance, as belonging to the hydrocarburets which I employ in my mixtures, common resin or colophony, tar, turpentine, or turpentine oil, after having treated them with nitric acid. I instance, as belonging to the pyroxylines which I employ, nitro-cellulose (cotton or wood, or any vegetable fibre). I include the different varieties of pyroxyline, and instance the form commonly called gun-cotton. I instance as nitrates those of baryta, potassium or sodium, lime and ammonium. By different combinations of these constituents I am able to produce every class of explosives suitable for all purposes. I can use them, for instance, in the place of dynamite, for blasting hard rocks or minerals, treating the convenient mixture under hydraulic pressure; or in the place of black gunpowder, for blasting rocks or minerals less hard, or in the bombs and shells of the artillery. I can also employ my explosive as a filling for cartridges to be used in coal mines subject to fire-damp. These cartridges will not ignite the fire-damp, and thus obviate a fruitful cause of accidents. I can also choose another percentage in mixing the three constituents, so that the explosive is then suitable as gunpowder for sporting and military purposes.

I will now give examples of the proportions to be used in preparing explosives according to my invention, but I wish to be understood that they are given as the best proportions with which I am acquainted for carrying my invention into effect, and that I do not limit myself to the precise details given in these examples, as I can advantageously vary the proportions in the same manner as the black gunpowder-makers can and do vary their proportions of charcoal, sulphur, and saltpetre to produce explosives suited to various requirements.

The proportions hereinafter given are by weight. A powder suitable for sporting purposes can be made according to my invention by mixing twelve parts of nitro-tar, or colophony, or turpentine, or turpentine oil, or mixtures of them, with sixty to eighty parts of pyroxyline, sixty to eighty parts of nitrate of baryta, and eight to ten parts of nitrate of potassium.

This mixture is prepared and granulated in the well known manner prevalent in making black gunpowder. I may add some binding material or not, and the grains of the finished powder may be coated or not with substances fit for this purpose, such as paraffine, resin, or collodion.

Not more than five-eighths of this gunpowder for sporting purposes thus produced should be used in the place of the quantity of black gunpowder that is generally used for this purpose. The propelling force of the sporting powder thus produced is excellent, and the rending force is not greater than that of black gunpowder, and it is free or nearly free from objectionable fumes, residue, and recoil.

A good gunpowder for rifles is produced by mixing ten parts of nitro-tar, colophony, turpentine, or turpentine oil, or mixtures of them, with two hundred and eighty to three hundred parts of pyroxyline, one hundred to one hundred and twenty parts of nitrate of baryta, forty to fifty parts of nitrate of potassium, and about ten parts of sulphur.

This mixture is to be granulated in the same manner as the sporting gunpowder, and should be employed in quantities of about two-fifths the weight of the quantity of black gunpowder used for analogous purposes—such, for instance, as that for military rifles. The finished powder may be coated or not, as mentioned with respect to the sporting powder.

My blasting explosive, suitable for use in blasting mild rocks or minerals, has a little proportion of pyroxyline. I may also add to this explosive a quantity of sulphur.

The proportion of the materials may with advantage be about ten parts each of pyroxyline and sulphur, fifteen parts of nitro-hydrocarburets, and seventy-five parts of saltpetre. The greater the proportion of pyroxyline the greater will be the power of the explosive produced, so that when an explosive is required for blasting hard rocks or minerals, the proportion of pyroxyline should and can be increased to suit the purpose for which it is required.

Having fully described my invention, what I desire to claim, and secure by letters patent, is—

The composition, consisting of a nitro-hydrocarburet (such as nitro-colophony, tar, turpentine, or turpentine oil), and of pyroxyline, and of nitrates or salts furnishing oxygen in combination with nitrogen, for shooting and blasting purposes, substantially as described.

According to the *Army and Navy Gazette*, **28**, 673; August 13, 1887, a series of trials has taken place at the Middlewick Ranges, Colchester, to test the relative merits of the Government cartridges, as loaded for the Enfield-Martini rifle, and others filled with a newly invented smokeless powder, which has been patented by Messrs. Johnson and Borland. The trial was carried out with a Gardner gun. The first trials consisted in firing 40 rounds of Government ammunition, so as to foul the barrel, and then 10 shots from the dirty barrel to test the accuracy. Although the gun had been well "laid" before the firing of the 10 shots, only 4 at 800 yards hit the target. The barrel was found to be very foul. The same number of shots were then fired with the "Johnson-Borland powder," with the result that in the last 10 of 50 rounds 8 struck the centre of the target. Then the barrels were inspected and compared and found comparatively clean. Indeed, once passing through the cleaning rod removed all residue, whereas it took 7 damped tows to clean the barrel in which the black had been fired. Trials for speed were then made, 40 rounds being fired in 5½ seconds. It was found that in consequence of the strain of the new powder being so small, the handle of the gun could be revolved with so much ease that the gun in rapid firing was not put out of position. The explosive force of the Government ammunition was such as to necessitate much more power being exerted in revolving the crank handle—a serious defect—whilst at the same time the "kick" was much greater. Besides this, the smoke from the Government ammunition was such that, after firing 20 rounds rapidly, the smoke accumulated so as to prevent No. 1 seeing through it; whereas with the new powder it was quite possible to see the bull's-eye at any time during the rapid firing. The velocity of the Government ammunition in the Enfield-Martini rifle is 1570 feet per second, which is the highest of any arm in the European service. With the new powder, 1800 feet per second has been arrived at. The experiments at Colchester show that the days are approaching when a smokeless explosive is likely to take the place of the present powder.

German Letters Patent No. 37631, October 14, 1885, have been granted to Friedr. Gaens, of Hamburg, for a gunpowder without sulphur, but which contains an ammonium salt, which will give rise to the formation of a potassium amine which is to be converted temporarily, at a higher temperature, into the explosive potassium nitride. (*Dingl. Poly. Jour.* **263**, 152; 1887.)

The *Scientific American*, p. 177, March 19, 1887, under the title Improved Gunpowder, states that A. H. Durnford has patented a process for making a soft charcoal which shall have an extremely low density, a low point of ignition, and slight hygroscopic properties, and which will produce a gunpowder possessing great energy and propelling power combined with moderate pressures when fired in a gun. The novelty consists in using charcoal made from cork by subjecting the cork to destructive distillation in cylinders at such a temperature as will produce the desired result. The gunpowder consists, first, of saltpetre and cork charcoal in the proportions of 80 to 20 respectively; second, of saltpetre, cork charcoal and sulphur, the latter being in proportions varying from 1 to 10 per cent. It is claimed that this powder is comparatively smokeless and non-hygroscopic.

It is now a well known fact that when compressed gun-cotton, dynamite, or other high explosives are freely exposed upon a metal plate and detonated, if the plate is sufficiently strong to resist rupture, the explosive leaves a marked and permanent impression upon the plate; the intensity of the impression being, of course, dependent upon the intensity and amount of the explosive used. This is not surprising when we recall that Berthelot found that gun-cotton having a density of 1.1 will develop, when in contact, a local pressure of 24,000 atmospheres or 160 tons on the square inch, and if we remember, too, that this enormous pressure is realized in an exceedingly brief space of time. The effect may of course be enhanced if the explosive be tamped with earth, water, etc. But, as Cooke* has so clearly shown in his essay on the "Air as an Anvil," the aerial fluid may serve as a tamp just as the aqueous one does, though not as efficiently.

It is perhaps not so well known a fact that the impression produced by the exploding mass is an almost exact copy of the form of that surface of the explosive which was in contact with the plate of metal. This feature is best observed with compressed gun-cotton, since, as it is a *papier-maché*-like body, it is possible to shape it as we fancy and to stamp upon its surface such figures and designs as we wish.

The first recorded observation of this phenomenon of which we are aware, is that made by Lieutenant Max Von Förster, of Walsrode, and a translation of his paper may be found in *Van Nostrand's Eng. Mag.*

* Pop. Sci. Monthly.

31, 113, August 1884. He says that when a piece of compressed gun-cotton is detonated on a plate of iron, an accurate impression of the form of the under surface of the gun-cotton is produced. Every angle, every projection, and every indentation present in the gun-cotton is impressed on the underlying iron, and he claims that this is due to the fact that the gases acting on the iron have occupied exactly the same space and no more than the solid explosive previously occupied, and thus transferred its form, and hence he concludes that only the gases evolved by the very undermost layers of gun-cotton act on the iron, while the others are lost.

In *Van Nostrand's Eng. Mag.* **32,** 1, January 1885, we have given an illustration of similar impressions which we had observed previous to meeting with Von Förster's paper, and we advanced the opinion there, and subsequently in our Notes,* that it was due to projection, the residual gun-cotton being driven into the metal by the explosion of a portion of the original mass, just as any other resisting body interposed in the path of the explosive wave would have been. Of course we are met here by the difficulty that this hypothesis implies (1) that the pressure exerted upon the residual mass of gun-cotton is transmitted more rapidly than the explosive reaction is propagated within the mass, and (2) it implies also a great rigidity or coherency for this mass. The last condition requires that which is a property of masses of matter when moving at high velocities, as in the well known candle experiment, and in the cutting of steel by soft iron, and the like. The difficulties presented in the first condition do not seem so great as those in Lieutenant Von Förster's hypothesis.

Some months subsequent to this, Commander T. F. Jewell, U. S. N., read a paper before the American Association for the Advancement of Science, on "the apparent resistance of a body of air to a change of form under sudden compression," and presented as an example of this phenomenon an iron plate upon which a disk of gun-cotton had been detonated. The letters U. S. N. and the figures 1884 had been indented in the surface of the gun-cotton, and similar letters and figures were found indented in the plate. He held that this was due to the fact that the air enclosed in the letters and figures, under the sudden and enormous pressure to which it was subjected, acted like a hard body and was thus driven into the iron. This paper appears in the *Proc. American Association* **34,** 81; 1886.

In a later pamphlet (Berlin, 1886) Von Förster again states that the

* Proc. Nav. Inst. **11,** 110, Feb. 1885.

gases generated by the detonation of the gun-cotton have, in the first instant, and as long as they exert their maximum force, the exact form and occupy the same space as was occupied by the gun-cotton before detonation, and thus they produce an exact impression of the surface of the gun-cotton in contact with it. He also says that the suddenness with which the power is exerted is shown by placing a leaf between the gun-cotton disk and the iron, for, after detonation, the whole frame or skeleton of the leaf will be found raised upon the iron. He explains that this is due to the larger as well as the smaller ribs of the leaf protecting the underlying parts of the iron, while the thinner parts between could not yield such protection, and under them the impression is deeper.

This was the condition of the subject when we again took it up experimentally in 1886. We first detonated gun-cotton disks upon which the figures and letters were indented, and obtained impressions on the plates in which these were also indented. Next we used disks having raised letters and figures, and obtained impressions in which these were raised. Next we cut deep channels in the disks, of various forms, taking care that they always communicated with the outer air so that there would be no air confined in them, and again these indentations were exactly reproduced in the iron. Next we filled the indented letters and figures, in disks such as Jewell used, with paraffine and with vaseline, so that the material was flush with the surface of the disk, and on detonation the letters and figures were found to have been obliterated. Next we struck, with stamps, the same letters and figures in an iron plate. This plate was laid face downwards on another iron plate and a lettered gun-cotton disk placed on top and detonated. The result was that while the gun-cotton disk produced the usual indented letters on the back of the top plate of iron, the top plate in whose letters and figures air was also confined and which was subjected to the same blow, produced raised letters and figures on the bottom plate on which it rested. These last three experiments certainly seem to prove that the air has nothing to do with this action. Again, when we consider how enormous the pressure is to which this air is subjected we must believe that, no matter how suddenly the force is applied, the air must undergo some compression, yet we find that the indentations in the iron are often nearly as deep as those in the gun-cotton.

In considering Von Förster's hypothesis, we are willing to admit that the gases at the time of detonation possess the exact form and

occupy the same space as the gun-cotton from which they are formed, if the change takes place instantaneously. But it does not; in fact, it occupies so appreciable a period of time that the rate of propagation of the detonation in it has been measured. Apart from this, and even granting it, it will be observed that Von Förster does not explain how the impression is to be produced by the gas. If the gas moves as a solid body, then the impressions should be the reverse of what we get.

From our experiments we are the more strongly convinced that the effect is a purely ballistic one, and that while the base of the gun-cotton, or its products, are projected as a whole against the plate, where the intervening spaces are the greatest there we have the greatest effect of impact, and consequently the greatest indentation. This is true in the leaf experiment, which has been exquisitely reproduced. The varying thicknesses of the leaf vary the distances through which the material is projected, and hence the form and texture are reproduced in the impression.

These experiments were described before the *Am. Assn. Ad. Sci.* in August, 1887, and the plates exhibited there have been very accurately and beautifully represented in the *Sci. Am.* **57**, 223, October 8, 1887; but the editorial description is inaccurate in some particulars. In the same paper are illustrations of the application of gun-cotton for testing the resistance of metals to shocks, as described in these Proceedings.* It should be stated that this method gives a means for revealing the inner structure of metals in masses such as we have never before possessed.

A new way of utilizing dynamite has been lately devised by a French military engineer, M. Bonnetond. He uses the expansive force to drive out, for a brief period, the water from portions of wet ground in which foundations are to be made. The method is now in practice in the construction of a fortified *enceinte* at Lyons. A hole is first bored 10 or 12 feet and about 1½ inches wide in the wet ground. Into this is passed a string of cartridges of dynamite, which is then exploded. The water is thus driven far out beyond the sides of the cavity, over a yard wide, which is produced, and does not reappear till after half an hour at least. The workmen thus have time to clear the cavity and introduce quickly-setting concrete. When the water returns it cannot injure the foundation. A rapid rate of progress is realized by this method. (*Nature*, **36**, 564; 1887.)

* Proc. Nav. Inst. **13**, 116; 1887.

The *Boston Globe*, July 22, 1887, notes that the balloon department of the German army is experimenting with a view to trying the destructive effect of dynamite hurled down upon forts from a balloon. In the *Sci. Am.* p. 181, March 19, 1887, W. Maxwell Maynard proposes that large fire balloons, to which a charge of dynamite is attached, be sent up among the rain clouds and discharged there in order to precipitate a rainfall in dry weather.

A new method of blasting without explosives has been recently introduced by Dr. Kosman, and is described in *Jour. Inst. Civ. Eng.* **87**, 41. Zinc powder and sulphuric acid are contained in a glass cartridge, by breaking which the two substances are brought in contact and hydrogen is rapidly evolved. A pressure of about 37,000 atmospheres is obtained, although, perhaps, with hardly sufficient rapidity to justify the use of the term explosion. (*Engineering*, **43**, 67, Jan. 21, 1887.)

A. Cavazzi, *Gazzetta Chimica Italiana*, in studying the reduction of potassium nitrate by various substances, has found that a mixture of equal parts of the nitrate and sodium hypophosphite detonates violently when heated to about the fusing point of the mixture. Other proportions yield explosive mixtures, but the above are the best. (*Sci. Am.* p. 181, March 19, 1887.)

H. N. Warren states in the *Chemical News* **55**, 289, June 24, 1887, that he has probably obtained "Fluoride of Nitrogen" or fluoramide, by passing an electric current from seven ferric chloride batteries through a concentrated solution of ammonium fluoride. After a lapse of a short time, several drops, of oily consistence, were observed attached to the negative plate. On becoming connected with the positive, a thin gold wire, these drops exploded with great violence. The compound is undoubtedly highly unstable, being at once decomposed in contact with glass, silica, or organic matter, thus rendering the analysis one of considerable risk. Its explosive violence is even greater than that of the chloramide, and it is also prone to spontaneous decomposition.

There was recently a prosecution, before one of the Prussian courts, of the agent of a banking house in Berlin, for jeopardy caused to a train of railroad cars. The main question was whether fuming nitric acid could, under the circumstances, occasion spontaneous ignition,

which, after hearing the testimony of the court's expert chemist, Dr. Jeserich, was decided in the affirmative. The agent had sent ten kilos (22 pounds) of fuming nitric acid from Berlin, intended for some point in Bavaria, per railroad. The acid was contained in a strong stone jar, tightly closed by a stone stopper and cement. The whole was packed in straw within a wooden case. Since such corrosive and dangerous liquids would not be transported by railroad as express freight, the contents of the box were represented to be clothing, and by this means the concealed acid was sent by a passenger train. During the journey, and when near Butterfeld station, the car containing the express freight was discovered to be on fire.*

Before the flames had made serious progress, the car was uncoupled and switched off on a side track, and the fire extinguished with comparatively slight damage, and no person was injured. Examination showed that the jar had leaked, and the acid had come in contact with a roll of woolen cloth, whereby the latter was set on fire. Dr. Jeserich gave it as his opinion that all woolen goods and all hair of animals, horn, etc., have the property of igniting spontaneously when coming in contact with fuming nitric acid; and he stated that all new explosives, about which there had been so much said and written lately, such as roburite, melanite, etc., are produced by the action of nitric acid on hair and wool. Herr Lack, the agent who made the misrepresentation about the acid, was condemned to two months imprisonment. (*Sci. Am.* **57,** 260; 1887, Abstr. *All. Vers. Presse*, Berlin.)

When preparing hypochlorous anhydride by the usual process, A. Mermet used liquid methyl chloride as a refrigerant instead of snow and salt. A violent explosion took place, the apparatus being destroyed and the assistant in charge had the lobe of his right ear torn. This catastrophe is ascribed to the vapors of the two liquids coming in contact. (*Chemical News* **55,** 249, May 27, 1887, Abstr. *Bull. Soc. Chim.* **47,** March 5, 1887.)

Scribner's Magazine, **2,** 197–221, August 1887, contains an interesting article by N. S. Shaler on the "Instability of the Atmosphere," in which the destructive effects produced by a sudden rush of gas are well described, and illustrated by numerous photographs. In speaking of the tornado he says that in its path over the surface, the circling movement of the writhing air and the sucking action of the partial

* Proc. Nav. Inst. **8,** 311; 1882, and **9,** 753; 1883.

vacuum in the central portion of the shaft combine to bring about extreme devastation. On the outside of the whirl the air, which rushes in a circling path toward the vortex, overturns all movable objects, and in the centre these objects, if they are not too heavy, are sucked up as by a great air-pump. Thus the roofs of houses, bodies of men and animals, may be lifted to great elevations, until they are tossed by the tumultuous movements beyond the limits of the ascending currents and fall back upon the earth. Where the centre of the whirlwind passes over a building, the sudden decrease in the pressure of the outer air often causes the atmosphere which is contained within the walls suddenly to press against the sides of the structure, so that these sides are quickly driven outward as by a charge of gunpowder.

It is not unlikely that the diminution of pressure brought about by the passage of the interior of the whirl over a building may be about as much as is indicated by the fall of four inches in the barometer. This is equivalent to a change in the pressure amounting to about 300 pounds to the square foot. This force operates to burst out the walls of a building. It is not improbable that the diminution of pressure may be much greater than this, but the amount named is sufficient to produce many of the effects noted.

These effects may be compared with those produced by the discharge of heavy ordnance or the blasts from high explosives.*

G. Masson, Paris, announces, in June 1887, the publication of Les nouveaux explosifs et la fortification, by le commandant Mougin.

* Proc. Nav. Inst. **13**, 408; 1887.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

OCTOBER 27, 1887.

LIEUTENANT AUSTIN M. KNIGHT,* U. S. N., in the Chair.

ALUMINUM BRONZE FOR HEAVY GUNS.

BY ALFRED H. COWLES.†

Mr. Chairman and Gentlemen :—The Government of the United States is equipping its fortifications and navy with new guns. Can we not improve upon the present armaments of Europe, instead of imitating them? If so, it is certainly an achievement worth striving for. I will endeavor to show that, with certain alloys of aluminum, we can increase *the life and destructive power, and diminish the cost and weight.*

How near can we approach to the requirements of a perfect gun metal? Assuming the carriage takes up the recoil, an ideal or perfect gun may be described as a gun of minimum weight and simplest construction, which shall be able to resist a maximum internal pressure in order to produce a maximum effect. Such a gun must be of one piece, in order to act like a great spring; it should respond very stiffly to the pressure of the powder gases, always perfectly recovering its original form; and its walls should be hard enough to withstand the abrasive action of the projectile. It is impossible to attain perfection. For safety, this great spring should have the property of stretching much beyond its elasticity,—thereby danger of violent explosion will be avoided. In practice, a gun must be considered a temporary structure. Its value is measured by its destructive power and its life, as related to its cost and its weight.

In order to make the nearest approach to the ideal gun, we must study the physical properties required of the metal to be used in its fabrication.

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† The author desires to give his brother, Mr. Eugene H. Cowles, due credit for much valuable assistance in the preparation of the following paper.

First, to withstand a high pressure of the powder gases, the metal around the bore of the gun must have as high an elastic limit as attainable, as it is this property that determines the pressure a gun will stand without distortion.

Second, and perhaps of greater importance, the distance the metal will stretch within its elastic limit, and yet perfectly recover itself, should be as great as possible. This gives the gun the character of a spring. To illustrate: If we take two guns made of different metals, the elastic limit of the metals in each case being the same, but the elastic extension of one being twice that of the other, the latter gun will have twice the power to resist heavy shocks, as it will act in resisting them with the same force through twice the distance.

Third, the metal of a gun should be as ductile as possible; and this ductility must be obtained without sacrificing a high elastic limit and elasticity, especially in the metal immediately surrounding the bore. As it will be shown later, this can be accomplished. The metal around the bore can be made to have great elasticity and a high elastic limit, and that of the outer portions of the gun great toughness. In 1865 Sir Wm. Armstrong stated that not one of 3000 wrought-iron "built-up" guns had burst explosively. Here he labored under the disadvantages of building up the guns, and using a metal of a low elastic limit and low elasticity; but clearly proved the value of great ductility.

Fourth, hardness in a gun metal has ceased to be one of the principal requirements. It is, however, desirable in a metal designed for the smaller sized cannon. It has been quite clearly demonstrated that a steel tube with thin walls can be inserted in the bore of a large gun, and made to withstand the destructive effect of the ball and the powder gases. When once destroyed it can be renewed at small expense.

With these points in view, we shall now proceed to discuss some of the difficulties that have arisen in the fabrication of large steel guns, and see if they cannot be overcome by the substitution of aluminum bronze, or some of the other alloys of aluminum.

In this brief article I need not refer to the many recorded failures of steel guns, and the known instances of cast-iron guns surpassing steel in endurance and approaching it in destructive power. The steel gun of to-day is built up of an aggregation of hoops and tubes, one shrunk or forced upon the other, in a vain attempt to carry out Captain Blakely's splendid conception of a gun so constructed that the initial tensions of the metal shall vary from the centre outwards

in order to correspond exactly with the variation of strain thrown upon its different parts at the moment of explosion. To accomplish this satisfactorily by building up a gun is generally conceded to be a mechanical impossibility. It is theoretically impossible to realize all the strength of the metal.* Mr. Longridge has mathematically demonstrated that in an 8-inch gun, twenty-three and six-tenths inches in diameter, composed of four rings *perfectly* fitted together, only 80 per centum of the full strength of the metal can be utilized. He has further shown that a mechanical deviation of one two-thousandths of an inch in the proper tension of a ring seventeen inches in internal diameter will render the condition such that this gun is no stronger than it would be were the metal in repose. This calls for such nicety in the work of building up a steel gun that practical men consider it impossible. A failure to learn the exact elasticity of the great masses of metal, variations in their elasticity, variations in their contraction during cooling, a dulled tool—any one of these causes would be sufficient to make such a small mechanical deviation as the above, which could readily pass unnoticed.

Again we have in a "built-up" gun the destructive effect of vibration. Alexander Holley† makes the following illustration: If an armor plate, built of a number of layers which are not fastened or welded together, be struck by a shot, two kinds of motion will be imparted to it: one tending to drive the plate bodily forward, and the other a wave motion, passing through the plates with a velocity about equal to that of sound through the metal of which the plates are composed. The layer struck will for an instant be reduced in thickness and extended in its other dimensions. When it recovers its original form by its elasticity, it will have in turn compressed the next layer, and so on until the last layer receives the shock. The inertia of this last plate tends to hold it in place until it is compressed. It is then in the condition of a spring, pressing equally in both directions, and resisted by a heavy mass on one side, but only by its own weight on the other, so that it jumps violently to the rear, tending to cause rupture or distortion. Were the plate solid, this tendency to separation would be overcome by the cohesion of the whole mass of the metal. In a "built-up" steel gun the tendency to this phenomenon is the more marked, as the external layers of metal are already under tension, and but a small wave motion is required to cause the metal to pass its elastic limit and cause distortion or rupture.

* See Alexander Holley's "Ordnance and Armor," pp. 248, 249.

† Holley's "Ordnance and Armor," p. 281.

Another evil, due to vibration, is exaggerated in a "built-up" gun. I refer to crystallization of the steel. To illustrate: It is well known that if a bell be made of two parts nicely joined, it will not give a musical note, but instead a deadened noise. This is due to the fundamental vibration being destroyed by the break in the metal, and the new vibrations formed interfere with one another, producing nodes and discord. A solid gun is to the "built-up" gun as a perfect bell is to the one described. By the present practice, when a gun is discharged, the inner layer of metal is distended almost to its elastic limit. This wave of distension passes outward, and is immediately superseded by a great number of reflections. These reflections are multiplied by the number of layers of metal in the gun, and their directions are governed by all variations in the form of the various parts. The amplitudes of vibrations of all these waves are greatest near the tube of the gun. Although the intensity of the fundamental wave is not great enough to stretch the metal beyond its elastic limit, whenever several of these reflections cross one another, the amplitude of the resultant becomes so great that the metal is either distorted or ruptured locally, and internal crystallization takes place.

Considering this fact, it would appear that the damaging effect is proportional to the square of the number of internal surfaces. In a tube or gun having homogeneous walls of uniform external and internal diameter, a vibration of the nature we started with would simply pass from the inner surface to the external and back again, and so continue until its energy was changed to heat or transmitted to the air, its waves of tension never interfering with their own reflections, so as to distend the metal beyond its elastic limit or tenacity and thereby cause crystallization. Hence it is, that if the nicely calculated adjustment of internal compression and external tension is ever attained in practice, experience has demonstrated that forming the gun of so many parts destroys the result attained, after a small number of discharges. These causes explain what is now called the "phenomenal endurance" of the cast-iron smooth-bore guns and of the converted rifles, and the fact, as I am told, that the Krupp Company will only guarantee their "built-up" steel guns to stand seventy-five service charges. Our Government has the record of several hundred 10-inch cast-iron guns converted into 8-inch rifles, no one of which has ever failed.

In order to learn further the efficiency of a solid gun as compared to a "built-up" gun, we shall compare the powder pressure attained in practice in cast-iron guns with that attained in steel guns. It is true that the cast-iron guns are now lined with steel or wrought-iron

tubes; their endurance, however, was equally marked without the tubes when quicker burning powder was used. On the other hand, the "built-up" steel guns are *supposed* to have the strength of their walls further developed in them by the principle of varying initial tension. The strength gained by this should be equal to that gained (due to the tube) in the cast-iron guns, and render our comparison fair.*

At the present day, with service charges, cast-iron guns have as an average about fourteen and five-tenths tons pressure to the square inch of surface of the bore at the moment of explosion. This is about equal to the tensile strength of cast iron. With steel guns the pressure is about twenty tons, or only forty-seven per centum of the

* Table showing the pressure of the powder gases in guns of similar calibres of steel, wrought iron, and cast iron; compiled from the table on page 100 of the Report on Heavy Ordnance and Projectiles: Logan Committee, 1883.

	Calibre.	Weight.	Length.	Twists in number of calibres.	Powder Charge.	Weight of Projectile.	Initial Velocity.	Pressure per square inch of bore.	Penetration of iron at 1000 yards.
	Ins.	Tons.	Ft.		Lbs.	Lbs.	Ft.	Tons.	Ins.
Steel Guns.									
German, from Essen.									
B. L. cannon of steel and steel hooped.—Krupp	15.75	71	32.8	1 in 45	484	1721	1702	20.9	31.81
" " "	13.97	51	29.13	1 in 45	253	1155	1642	22.	24.97
" " "	12.	36	22.	1 in 72	143	664	1517	19.5	16.12
" " "	15.75	71	32.8	..	462	1762	1695	16.90	25.
							Average Pressure,	19.82	tons.
Wrought-Iron Guns.									
M. L. coiled wrought-iron cannon, tube of cast steel.—English, Elswick	17.72	100	32.9	1 to 150 to 1 in 50 near muzzle.	463	2010	1640	21.	25.88
M. L. coiled wrought-iron cannon, tube of cast steel.—English, Woolwich	12.5	38	18.75	From 0 to 1 in 35.	200	800	1590	21.	17.97
B. L. coiled wrought-iron cannon, tube of cast steel.—Woolwich	12.	43	27.75	..	311½	700	1950	18.7	20.01
M. L. coiled wrought-iron cannon, tube of cast steel.—Frazier's System	16.	80	26.9	..	460	1760	1626	20.5	22.13
							Average Pressure,	20.05	tons.
Cast-Iron Guns.									
B. L. cast-iron cannon, hooped with steel.—General Rossit's System, Italian	18.1	87	29.52	1 in 60	440	2200	1378	15.8	14.13
	12.6	38	22.5	1 in 70	158	770	1492	12.6	16.63
M. L. cast-iron, lined with coiled wrought-iron tube.—U. S.	12.25	40	21.81	1 in 70	115	700	1485	15.	15.75
B. L. cast-iron, hooped with steel. Italian, Turin	17.72	100	32.8	1 in 60	485	2204	1512	14.5	23.87
M. L. cast-iron rifle, converted from 15-inch Rodman. At Sandy Hook fired 401 rounds.—U. S.	11.	24.3	16.6	1 in 59.8	90	543	1352	14.68	13.52
							Average Pressure,	14.51	tons.

tensile strength of gun steel. In other words, with a strength of metal *three times as great, only thirty-three per centum increase in efficiency* is obtained in a "built-up" steel gun over one of solid cast iron, and the latter has *far greater endurance.*

It must be understood that these pressures are average results. Cast-iron guns have repeatedly been known to stand pressures far above the tensile strength of the metal without apparent rupture, but it is doubtful whether a steel gun has ever stood such a test.

In Table I. we have the average physical properties of the metals now used in the fabrication of guns.

Table II. gives us a slight insight into a field of aluminum alloys which up to the present time has scarcely received investigation. On the testing machine at the works of the Cowles Electric Smelting and Aluminum Company, at Lockport, N. Y., higher results have been obtained, and other alloys made in small quantities whose physical properties have surpassed these.

TABLE I.

Physical Properties of Gun Metals now used.

METAL.	Elastic Limit.	Elastic Extension per unit length.	Tensile Strength per square inch of original section.	Elongation per centum after rupture.	Contraction of Area per centum.	Modulus of Elasticity.	Compressive Strength per square inch.	Hardness. U. S. Standard.	Specific Gravity.
	Lbs.		Lbs.			Lbs.	Lbs.		
STEEL. Average properties of 137 specimens of accepted gun steel from hoops, jackets, and tubes, oil tempered and annealed. U. S. Government tests	51,611	0.00207	96,150	19.93	41.	About 29,000,000	....	21.4	7.86
Same grades of steel not oil tempered and annealed, average of 19 specimens	38,140	0.0016	88,000	18.7	31.	....	....	14.9	7.86
Cast gun steel, German soft (Alexander Holley, "Ordnance and Armor")	35,392	0.00096	70,784	....	....	....	200,000	....	7.8
WROUGHT-IRON FORGINGS. Small bars { Highest	30,000	0.0016	73,000		....	....	80,000	....	7.77
Small bars { Mean	18,000	0.00065	53,000	26.					
Heavy forgings, average of 700 tests at Sir Wm. Armstrong's works	23,760	....	48,160	....	....	....	....	....	....
CAST IRON. Average of four Watertown tests of accepted iron	17,000	0.0009	36,000	0.166	nil	....	125,000	19.96	7.25
GUN BRONZE. Average of fourteen Watertown tests	13,214	0.0012	38,995	33.6	33.0	....	....	6.	8.12

TABLE II.

Physical Tests on a few Aluminum Alloys.

ALLOY TESTED.	Diameter in inches.	Cross Section in square inches.	Length between marks in inches.	Elastic Limit, pounds per square inch.	Elastic Extension per unit length.	Tensile Strength, lbs. per square inch of original section.	Elongation per centum.	Contraction of Area, per centum.	Hardness.	Modulus of Elasticity.	Specific Gravity.	
A_1 Bronze, old name Special Composition, Cu 89, Al 10, Si 1	0.5	.....	2	.....	.....	114,514	4.5	.0	...	.....	7.56	Washington Navy Yard Tests, Feb. 16, 1886.
	0.501	.....	2	69,749	.....	95,366	0.5	.6	...	.....	...	
	0.501	.....	2	79,894	.....	109,823	0.5	2.39	..	.....	...	
Bars cast in sand. Maximum strength sought		.0646	1	.....	.....	128,000	.0	.0	...	.....	...	Tested at Leeds Forge, England.
	0.304	.....	1	.....	.....	97,380	.0	...	...	.....	...	Watertown Testing Machine, July 11, 1887.
	0.315	.. ...	1	.....	.....	115,260	.0	...	...	.....	...	
	0.272	.....	1	.....	.....	118,590	.0	...	...	.....	...	
* A_1 Bronze, forged at red heat	.798	.5	10	38,000	0.00232	81,700	5.2	11.4	...	17,544,000	..	Watertown tests, April 29, 1887.
	.798	.5	10	41,000	0.00259	87,600	2.	8.6	...	17,241,000	...	
A_2 Bronze, cast in sand	.321	.0809	1	.....	.....	87,510	17.	...	...	.....	7.65	Watertown tests, July 11, 1887.
A_2 Bronze, forged	.503	.199	2	.....	.....	83,820	35.5	43.2	...	.....		
A_3 Bronze, Composition Cu 91¼ per cent, Al 7½ per cent, Si ¼ per cent. Cast in chill mold		1.	6	21,500	0.00133	69,800	32.8	32.1	13.46	16,520,000	7.8	Watertown, July 11, 1887.
		1.	6	24,000	0.0018	68,000	18.2	26.1	11.8	16,300,000		
	.312	.....	1	.....	.....	74,770	25.	...	...	.....	...	Watertown, July 11, 1887.
	.327	.....	1	.....	.....	68,930	48.	...	...	.....	...	
	.327	.....	1	.....	.....	71,790	40.	...	...	.....	..	
Aluminum Brass No. 1. Composition 71¼ per cent Cu, 3¾ per cent Al, 25 per cent Zn. Cast in chill.		1.	6	21,500	0.0018	63,450	11.2	23.	9.2	14,070,000	...	Watertown, July 11, 1887.
Aluminum Brass, No. 2. Composition Cu 63⅓, Al 3⅓, Zn 33⅓. Chill casting	.....	1.	6	47,000	0.0091	76,800	3.5	8.4	12.6	13,490,000	...	Watertown, July 11, 1887.
Small bars cast in sand. Made by Electric Co.	.306	.....	1	.....	.....	91,500	9.	11.4	..	.....	...	Watertown.
	.296	. ....	2	.....	.....	88,950	4.	7.3	...	.....	...	

* Compression tests of A_1 forged bars 2" x .798" diameter, 160,400 lbs. to the square inch, and 153,600 lbs. to the square inch: Watertown, April 29, 1887.

With alloys of these physical properties at command, which can be cast more readily than cast iron, there are two well-tried methods of fabrication that might be employed to give us *solid* guns of great destructive powers and endurance.

First, the Rodman method of casting a gun, and cooling it from the centre during the solidification of the metal. Were this employed, we might adopt the A_1 bronze, having a tensile strength of about one hundred thousand pounds to the square inch, a hardness greater than cast iron, and an elastic limit four times as high. The extension within the elastic limit is over three times that of cast iron; hence, its power to resist shocks would be, as compared to a cast-iron gun, proportional to the products of the elastic limits of the two metals into their elastic extensions, or about as twelve is to one. We should still have some ductility in reserve, which cast iron has not. In casting aluminum bronze by Rodman's method, we should be enabled to overcome one very serious difficulty that existed in casting iron guns. The temperature at which this grade of bronze solidifies is only about sixteen hundred degrees Fahrenheit, as compared to twenty-seven hundred degrees, the melting temperature of cast iron. With this low temperature, we could heat the outside of the mold as hot as the molten metal, and thereby cause all cooling to take place entirely from the centre, which we know would be the ideal perfection of the Rodman method of casting guns.

The destructive effect of heat upon gun bronze is a serious objection to the use of that metal. An interesting experiment, performed by Lieutenant M. E. Hall, U. S. N., and myself, illustrates the peculiar fitness of this grade of aluminum bronze to overcome this difficulty. There were cast two bars of A_1 aluminum bronze, attached to the same gate in the sand. One, on testing, developed one hundred and nine thousand one hundred and twenty pounds tensile strength to the square inch, and five per centum elongation. The duplicate was then placed in the machine and strained till it was resisting one hundred thousand pounds stress. It was then heated by a blowpipe flame to a temperature at which cotton waste would char when placed against the bar (about 400° F.), and while so heated the strain was increased to one hundred and seven thousand pounds to the square inch. It was then allowed to cool down to the temperature of the room and again tested, when it stood one hundred and ten thousand one hundred and sixty-two pounds to the square inch without breaking. On heating the bar again to the temperature

of charring waste, it broke at eighty-six thousand pounds, and had developed about four per centum elongation. We concluded that its finally breaking at a lower tensile strength than it had already stood in stress upon it, under apparently the same conditions, was either due to an inequality in the temperature, or to the fact that the strain of one hundred and ten thousand pounds had caused a partial rupture. From this experiment we became fully convinced that this grade of bronze retained its remarkable strength through a great range of temperature.

The second, and probably the best method to follow in the fabrication, is one invented by the late Samuel B. Dean, of Boston, which is now used in making cannon from tin bronze.* In Great Britain, in 1870, the Committee on Field Artillery for India reported in favor of and adopted this method. Our Government Ordnance Bureau ordered guns to be made by the Dean process in July, 1870, and the work was subsequently interrupted in consequence of the neglect of Congress to vote the necessary funds. The Austrian artillery adopted the process in 1873, and since then have used it exclusively. The credit of the invention is there given to General Uchatius. The gun is first cast solid in a chill mold. It is then bored, and conical chilled steel mandrels of gradually increasing diameters are successively driven through the bore by hydraulic pressure. The metal around the bore is thereby given greater strength and hardness, a higher elastic limit, and a greater elastic extension. These properties gradually vary till the outer circumference of the gun is reached, where the metal has its normal condition of great toughness. An exhaustive series of experiments made by General Uchatius resulted in the selection of a bronze for a gun so constructed containing ninety-two parts copper and eight parts of tin, this being the copper tin alloy having the greatest combination of strength and ductility. Cast in a chill to cause the tin to form a homogeneous alloy with the copper, he obtained the following properties:

Tensile strength, . .	43,200 pounds to the square inch.
Elastic limit, ...	5,672 " " "
Elastic extension, . .	0.0004 per unit length.
Ultimate elongation, .	40 per centum.
Hardness, ...	5.

* See pp. 530 to 540, Part 3d, "The Materials of Engineering," by Robert H. Thurston, A. M., C. E.

The inner walls of a cannon made of this metal, and hardened by mandreling, developed the following physical properties:

Tensile strength, . .	60,350 pounds to the square inch.
Elastic limit, ...	15,620 " " "
Elastic extension, . .	0.00306 per unit length.
Reduction of area, . .	44 per centum.
Ultimate elongation, .	16.5 "
" Hardness nearly equal to that of gun steel "(?).	

Were the A_3 aluminum bronze substituted for the above (so-called) "steel bronze," we would start in the original casting with the following properties:

Tensile strength, . .	70,000 pounds to the square inch.
Elastic limit, ...	23,000 " " "
Elastic extension, . .	0.0018 per unit length.
Reduction of area, . .	30 per centum.
Ultimate elongation, .	40 "
Hardness, about . . .	13.

By mandreling, the strength of this metal in the bore could be increased to over one hundred thousand pounds to the square inch, and the elastic limit raised to sixty or seventy thousand pounds. The stretch within the elastic limit would be increased, and, as other tests than those given show, would far surpass that of gun steel. The outer portion of the walls, where the strain is not as great at the moment of explosion, would have a *great reserve of ductility*. It would be impossible to burst such a gun with four times the powder pressure now used in the steel "built-up" gun. The walls would be *solid*. There would be *no danger of crystallization*. *No rust* or *verdigris* can form on aluminum bronze. The finished gun would have the color and lustre of gold. It would not be affected by salt water. The fabrication of such guns would not require a great outlay of capital invested in plant, and the mineral resources of our country are capable of supplying in inexhaustible quantities the raw material necessary for the production of the aluminum alloys. Were our Government enabled to make a great advance in the art of gun fabrication before equipping itself with the guns now needed, it would render valueless, against us, the present armaments of Europe.

There is one more point to be considered, viz., the cost of aluminum bronze guns as compared to steel guns. In the following table we see that the average cost of steel guns in Europe is about fifty-

three cents a pound, and of cast-iron guns (finished, tubed, and hooped with steel), fifteen and one-tenth cents a pound.

TABLE SHOWING THE COST OF STEEL AND CAST-IRON GUNS IN EUROPE.

Steel.

	Calibre in inches.	Weight in tons.	Cost per ton.
Whitworth,	9.75	8.02	$ 824
Krupp,	13.98	51.18	1,300
Krupp,	12.	35.42	1,012
Krupp,	10.23	21.65	941
Krupp,	5.9	4.97	1,076
Krupp,	5.9	3.44	1,074
Krupp,	5.9	3.94	1,176
Average,	9.09	18.37	$1,057, or 53 cents per pound.

Cast Iron.

	Calibre in inches.	Weight in tons.	Cost per ton.	
French,	9.45	15.91	$349	Hooped and tubed with steel.
Italian,	9.45	14.91	305	
Italian,	9.45	17.02	307	
Italian,	12.6	37.40	259	
Italian,	12.72	99.	293	
Average,	10.73	36.85	$302, or 15.1 cents per pound.	

Table compiled from page 97, Report on Heavy Ordnance and Projectiles, Logan Committee, 1883.

In this country these prices would be forty per centum higher, or about seventy-five cents a pound for finished steel and twenty-one cents for cast-iron guns. Here we have the data to arrive at the cost of aluminum bronze guns as compared to steel. The cost of fabrication would be about the same as with cast iron. Assume that the iron in cast-iron guns costs two cents a pound; deducting this from twenty-one cents we have nineteen cents per pound as the cost of fabrication. Aluminum bronze is on the market at forty cents per pound. Add to that nineteen cents, and we have approximately the cost of the finished aluminum bronze gun as fifty-nine cents a pound.

We have shown that the strength of the bronze is so great that the finished gun need weigh no more, if as much, as a steel gun of like calibre. Hence we arrive at the fact that to-day heavy guns of aluminum bronze can be made at *twenty per cent less cost* to the Government than like guns of steel; and further, *sixty-eight per centum of their cost is represented by capital stored away* in the form of a valuable metal that can *be remelted and used over any number of times* without alteration of its composition.

I close, gentlemen, with the question, Would it not be well for our Government to appropriate ample funds to investigate this promising field, and learn wherein these alloys can be applied in the construction of ordnance and armor?

DISCUSSION.

The following, contributed by Mr. J. W. Richards in response to the invitation extended him to discuss the foregoing paper, was read to the meeting by Mr. Eugene H. Cowles.

By way of introduction, Mr. Cowles said that it would be of interest to the audience to know something of Mr. Richards. This gentleman was the author, he said, of what might justly be regarded as the best treatise on aluminum that had been published since the appearance of De Ville's profound and yet charming brochure on the subject in 1859. In addition to being a careful and well informed writer on the subject of aluminum, he is also a painstaking scientific investigator of the metal and its alloys.

A RESUMÉ OF THE HISTORY OF ALUMINIUM.

By Joseph W. Richards, M. A., A. C.*

About 1760, Morveau called the substance obtained by calcining alum, alumina. When, afterwards, alumina was suspected of being the oxide of a metal, the metal was called aluminium. This, long before it was isolated.

In 1807, Davy tried to decompose alumina by the battery, with which he had decomposed potash, soda, lime, baryta and strontia, but in this case he failed completely. He tried other methods of reduction, but was no more successful. Berzelius and Oerstedt were among the many chemists laboring at this problem, and Oerstedt, in 1824, thought he had isolated the metal, but he was proved to be mistaken. In 1827, Wöhler, following a process not very different from

* Instructor in Metallurgy in the Lehigh University, Bethlehem, Pa.

Oerstedt's, heated aluminium chloride with metallic potassium, and was successful in isolating aluminium as a grey, lustrous, metallic powder. In 1845, Wöhler improved upon his first process so far as to get small globules, about as large as pins' heads, from which, with consummate skill, he determined pretty accurately the principal properties of aluminium. Thus, while aluminium had been isolated in 1827, for eighteen years its properties "en masse" were unknown, and it was only at the end of twenty-seven years after its discovery that the true properties of the pure metal were established by Deville. The second birth of aluminium, the time at which it stepped from the rank of a chemical curiosity into the number of the useful metals, dates with the labors of Henri St. Claire Deville, in 1854. If Wöhler was the discoverer of aluminium, Deville was the founder of the aluminium industry.

Deville's first success was an accident. He was using Wöhler's method, with some modifications, trying to produce proto salts of aluminium which would correspond with the proto salts of iron; when lo! on finishing one of his experiments, there unexpectedly greeted his sight a metallic globule, a button of pure aluminium, the first time seen pure and "en masse" by human eye. Deville bothered himself no more with the proto salts of aluminium. He recognized all the grand importance of his discovery, and turned all his attention to producing the metal economically. It was a grand problem brought before a master mind. Deville at this time was Professor of Chemistry in the École Normale, Paris. He was practically without the means with which to undertake such an investigation, for his salary was only 3000 fr. ($600), and his estate was small. But he gave a hint to the French Academy of Sciences, and not in vain. He read them a short paper at their séance on Monday, February 4, 1854, simply describing his discovery. The Academy immediately became interested. M. Thenard rose and remarked that he thought it to be the general opinion that such experiments should be actively followed up, and that such experiments being costly, the Academy could hasten the accomplishment of the work by placing at M. Deville's disposal the necessary funds. In a short time after the meeting, Deville was made one of a committee to experiment on producing aluminium, and 2000 fr. were placed at his disposal. With this he labored hard in his laboratory in the École Normale, aided by M. Debray, and on August 14th of the same year he read a paper to the Academy explaining the methods he had pursued, and showing as the result several bars of aluminium. He also caused a medal of aluminium to be struck, which he presented to the Emperor, Napoleon III. The latter, with that enlightened spirit so characteristic of the French people, and especially of Napoleon III., immediately authorized experiments to be continued at his own expense on a large scale. Deville, however, about this time accepted, in addition to his duties as Professor at the École Normale, a lectureship at the Sorbonne, and so we find that it was not until March of the next year that the experiments at the cost of the Emperor were begun. They were then instituted on a large scale at the chemical works at Javel. These experiments lasted three months, until June 29th, and were accompanied with such success that on June 18th Deville presented to the Academy, through M. Dumas, large bars of pure

aluminium. The members and the numerous auditory were loud in their admiration and surprise at the brilliancy and beauty of the metal. Dumas stated that the experiments at Javel had put beyond a doubt the possibility of extracting aluminium on a large scale by practical processes, besides giving to science a reducing agent of the highest importance at a moderate price, namely, sodium. Thus, besides aluminium, many other metals hitherto unknown to industry would be brought into practical use as the result of these experiments. After these remarks of M. Dumas, Deville's paper was read, describing all his processes in detail, and in which he concludes as follows: "After four months of work on a large scale, undertaken without responsibility on my part, and, in consequence, with the tranquillity and repose of mind which are so often wanting to the investigator, without the preoccupation of expense, borne by his majesty the Emperor, the generosity of whom had left me entire liberty of action, encouraged each day by distinguished men of science—I hope to have placed the aluminium industry on a firm basis."

Such was indeed the result of the Emperor's liberality. It is said to have cost him 35,000 fr. ($7000). Do you not agree in thinking that the return was out of proportion to the cost? Listen to the testimony of facts as to the result. A quite recent writer says: "In consequence of this Government subsidy the industry of aluminium was able to date its commencement, for at that time the necessary experiments were costly and could not bring commensurate return to the individual experimenter." Another writer says, "France was the first to produce aluminium on a practical scale, and *it is the only country in which the industry has really prospered.*" Still another writer says, "*France seems to be the only country in which the industry is able to prosper*"—and that was said by a German.

In contrast with this showing for France, compare this incident taking place at home. Mons. Monnier, of Camden, N. J., as early as 1856, became successful in producing sodium cheaply and made some aluminium, which he showed to the Franklin Institute, Philadelphia. He was desirous of experimenting further in this direction, and in this connection the Mining Magazine suggested "the propriety of giving him aid at the expense of the Government; for the introduction of a new metal into the arts is a matter of national importance, and no one can foresee the various and innumerable uses to which a new metal may be applied. Moreover, it would be quite proper and constitutional for Congress to appropriate a sum of money to be expended in the improvement of this branch of metallurgy and in testing the value of the metal for coinage and other public use." The Franklin Institute Journal also remarked: "This is just one of those enterprises which no manufacturer could afford to pursue at his own expense, and for the simple reason that he would gain no adequate equivalent for his labor, because all would participate alike with him in the benefits of his researches. Nothing can give a greater impetus to manufacturing industry in its present state than the introduction and use of new natural products, and we hope to see the *Government* take up and pursue this work still farther."

Such a policy was never acted upon by our Government. As the result, what advancement has our country made in this branch of science and industry?

It is the nurturing and fostering of industries in their infancy which makes the "effete monarchies" of the Old World still our superiors in so many industrial fields.

Now, to return briefly to Napoleon III., what were his motives? I think, unhesitatingly, they were to foster science and thus enhance the industrial renown of France. And truly, never was renown more cheaply purchased. As a second thought, it is said that the Emperor looked forward to applying such a light metal to the helmets and armor of the French cuirassiers; and, although the first article manufactured of aluminium was, in compliment to the Emperor, a baby-rattle for the infant Prince Imperial, yet the second was a helmet, beautifully gilded and decorated, for the Emperor's cousin, the King of Denmark, which weighed complete only one pound three ounces.

The occasion of this meeting gives rise to quite a coincidence. Napoleon encouraged and really made possible the aluminium industry by looking forward to the industrial credit of the nation, and also to the improvement of the materials of war. To-day's discussion is urged by the promoters of a new industry seeking Government co-operation in bringing into use a metal which all indications and experience unite in commending as promising to be eminently suitable for war purposes. Government co-operation in this case can be looked on more in the light of a judicious investment than merely the general encouragement of science.

As far as aluminium bronze is concerned, its history is contemporary with that of aluminium, and probably has been or will be given at length by others in the meeting. I merely remark that of all the alloys of aluminium, the bronze is deservedly the best known because of its recognized exceptionally valuable qualities. As to its suitability for heavy guns, while knowing the elementary requirements of gun material, I am not familiar enough with the theory and practice of gun building to intrude any remarks of mine on this subject into a discussion in which such recognized authorities are present to take part. However, let me state that the most recent action of the Italian Government, in the artillery line, is the replacement of 4000 steel field-pieces by bronze or gun-metal pieces; the advantage of the latter being that while as safe from bursting and as effective as steel guns of equal weight, they can be cast at much less expense and to greater perfection than the steel guns. Such being the advantages in using ordinary gun bronze, let me ask if it is not in the power of our Government to take a step in advance of the best and most recent modern artillery practice, by undertaking to cast its heavy guns of aluminium bronze?

Mr. EUGENE H. COWLES.—*Mr. Chairman and Gentlemen:*—I desire to state here, that in entering this discussion, our idea has not been to seek such Government patronage as has been described by Mr. Richards in his paper. I am glad to state that such aid is not at at all necessary to our success, even were it the habit of this Government to extend its aid to promising inventions; for the Cowles process of electric smelting is far beyond that embryonic state that requires such patronage. Our real motive for entering the discussion may be briefly stated thus: A large plant for the production of aluminum alloys

has been erected at Lockport, New York, and another is in process of construction at Stoke-on-Trent in England; these alloys are being produced in large quantities, and the process is in every way a commercial success; and, finally, with these facts in view, we deemed it proper to extend the market for our alloys wherever possible. We are, consequently, most happy to avail ourselves of this opportunity to discuss the scientific possibilities of aluminum alloys before the Institute, and thus to introduce the matter generally to the naval and military engineers throughout the world.

The following telegram and letter were here read by the Secretary and Treasurer:

PARIS, FRANCE, *Oct.* 27, 1887.

Lieutenant MILES, *Secretary, Naval Institute, Annapolis, Md.*

Received circular letter too late to respond from here, but want to report following fact: A cannon, a mountain artillery gun of aluminium bronze was cast and tested in 1859 by the Committee of Artillery of France. Constant firing, such as would ruin a steel gun, caused only a slight swelling of chamber, and attempts to explode it with heavy charges were also futile. A scientific engineer, School of Liege, Belgium, has responded to your invitation. It cannot reach you until Monday. He reports an experiment with aluminium bronze cast cannon by Colonel Weber, Manager Royal Foundry, Augsburg, Bavaria, 1860, in which the results were highly favorable. It was pronounced by the French Committee and by Weber that the then high cost of aluminium was the only thing prohibitive of its widespread use for guns, it possessing sterling qualities.

BEN. M. PLUMB.

PITTSBURGH, *Oct.* 19, 1887.

Lieutenant CHAS. R. MILES, *Secretary, Annapolis, Md.*

Dear Sir:—I have your esteemed favor of October 17th. . . . . I am on record as a pronounced enemy, or rather opponent, of the "built-up" guns.

Allow me to say, however, that I think there has been enough said on that subject. The built-up system has been adopted by the Government, and, good or bad, I believe it to be wiser for citizens to sustain our officers, and to try to help them to get appropriations enough to supply us with a respectable armament.

Therefore, if I am not attacked I shall oppose no more, until we have a navy and some heavy ordnance; after that is accomplished, if any person wishes to open up a discussion that can do no harm, it will be entirely proper for us all to go at it again.

For the present I prefer to use my influence in favor of that system which has been approved officially.

I shall not be able to attend your meeting, and you are at liberty to use this letter as you may see fit. Yours respectfully,

WM. METCALF.

The discussion was then continued in the following order:

Professor R. H. THURSTON.*—*Mr. Chairman and Gentlemen:*—The paper of Mr. Cowles is to me a very interesting and a very suggestive one. The use of a new metal in the arts, and especially for important purposes, such as the construction of ordnance, is always a matter of singular interest. The introduction of a new system of metallurgical operation in conjunction with the production of a new class of alloys is of such extraordinary importance as to mark an era in industrial history. I regard the introduction of the Cowles methods of manufacture of the aluminium and other alloys as just such an exceptional event, and as one likely to revolutionize, not only the methods of production of this class of alloys, but of many branches of manufactures.

I have watched its development and progress with very great interest from the first, and have been exceedingly pleased with the business-like ways and the scientific methods applied in the building up of this new industry. The application of heavy currents of electricity to the melting of refractory substances and to the production of alloys is in itself a commercial and industrial revolution. The derivation of enormously intense and powerful currents by the use of water power, and thus at minimum cost, is a purely commercial revolution of an importance which can hardly yet be realized. The introduction into our markets of metals having the singular and valuable characteristics of aluminium, at such prices that they may have general practical application, is one of those occurrences which only very rarely punctuate our social history. The possibility of rendering available for useful purposes numbers of as yet almost unknown elements and compounds which is thus opened to us, is one of those matters which must be regarded as of extraordinary interest and promise, the outcome of which must be entirely beyond our present view or conception; which may probably be paralleled only by such events as the production of cast iron by Dudley, of wrought iron by Cort, of steel by Huntsman, or the modern "ingot irons" by Bessemer and by Siemens.

I have studied the operation of the Cowles furnaces with all the interest that is compelled by so novel a process and such remarkable products, and have felt that the only question as to its success must be the commercial one, and that must be settled by actual business in the markets of the world. It is gratifying to be assured by the inventors that this is no longer a question, and that the possibility of making such alloys as they have produced, and of being able to put them in the market at fair prices, and at a moderate profit, has resolved itself into a certainty. This being the case, the introduction of the process and of its products would seem to be as well assured as any matter of business can well be. The last is a subject of prime importance where it is proposed to make application of the alloys so made in the construction of ordnance. It would be unwise to venture upon predictions as to the final outcome; but this at least may be said, that we may expect much from so radical an advance in metallurgy, and that we may reasonably hope for almost as great results in the production of alloys as came, in another field, from the invention

* Director of Sibley College, Cornell University, and formerly of the Engineer Corps, United States Navy.

of the great metallurgical processes which now give to the world its various ferrous products.

Considering the application of the newly available alloys to the construction of ordnance, it is first necessary to determine what are the essential qualities of ordnance metal. These I should state in the following order:

1. Tenacity sufficient to meet safely the maximum pressures and stresses due to the heaviest charges and quickest powder to be employed in the gun made of it.

2. Ductility sufficient to resist accidental as well as ordinary strains without danger of fracture and explosion.

3. Hardness sufficient to bear the abrasive action of the shot and its shearing action on the lands of the bore.

4. Elastic "resilience" such that it may not be in the slightest degree deformed by the shock of successive charges.

5. Power to retain the useful and essential qualities which have been above described, at all temperatures, which may be attained in the most rapid firing, even approaching the red heat, if possible.

In the discussion of the paper by Mr. Dorsey, on steel for ordnance, I remarked that I should expect the best metal to prove to be that having the highest ductility consistent with sufficient hardness, which would, in that case, be one of the mild steels, as distinguished from the tool steels; perhaps high in carbon for a steel of that class, but low as compared with the older kinds of steel.* The experience of Mr. Metcalf would indicate, as stated at that time, that it is very possible that as high as 0.80 per cent carbon, corresponding in the unannealed metal to a tenacity of about 100,000 pounds per square inch (Materials of Engineering, Vol. 2; Iron and Steel, §234, pp. 417–421), may be taken as allowable in steel, and as representing the maximum limit for the best; but only, I should say, when exceptional ductility can be at the same time obtained. In other words, a soft tool steel or a hard "open-hearth" product may be taken as representing an ideal material in these respects. The demand should be for a metal having the greatest possible ductility consistent with sufficient hardness and tenacity; the elastic limit being exactly specified at a point in excess of the maximum pressures to be met with, and a minimum figure being given for the elongation to be secured. Steel of 0.80 per cent carbon has an elastic limit, in good samples, of not far from 50,000 pounds per square inch. Its elastic "resilience" is not far from 4000 foot pounds per unit of section and of length. A total extension of 15 per cent, I should say, ought to be expected as a minimum in such steels. Any metal or alloy which is capable of such an extension and of exhibiting such tenacity, in equally large masses, and which at the same time is not too costly in production and application to this purpose, should be considered as a candidate for similar position among the materials to be used in the construction of ordnance.

* This opinion was, in the course of the debate upon that paper, misinterpreted and taken to mean the endorsement of "soft" steel, in the sense in which that word has of late come to be used by those who are familiar only with the "mild" steels as a class. The latter would make a steel of one-half per cent carbon a hard steel, while it would be a soft steel when considered in the intended classification.

The question whether a gun shall be solid or "built up" is, I conceive, usually to be settled by a consideration of the possibility and the practicability of securing in large masses anything approaching the maximum strength of the material as exhibited when used on a small scale It is not ordinarily possible to secure such tenacity when working in wrought iron, and it is only possible, when using steel, by the adoption of the Whitworth or an equivalent process of compression or solidification. With the cast metals, also, it is not usual to find equal or nearly equal strength in small and in large masses. But could this natural strength, as I would call it, be secured in the solid, as distinguished from the "built-up" gun, there is no difference of opinion as to its desirability to utilize it in one, rather than in a composite, piece. A built-up gun may be taken as an attempt to correct one wrong by the introduction of another; to balance a lack of tenacity produced by the ordinary methods of solid gun construction by the use of a complicated, and, to a certain extent, dangerous assemblage of parts, each of which possesses more nearly the desired tenacity.

In choice of material and of method of construction, therefore, I would most certainly look for a strong and tough metal which could be easily and inexpensively worked into large masses of uniform and maximum strength. The best and the only satisfactory illustration of such construction of which I am aware is the Whitworth gun, and that is not fully satisfactory on account of its cost. As regards weight, I should say that, for a gun which is muzzle loading, and usually therefore allowed necessarily to recoil, a certain weight is necessary and desirable to secure proper control of the gun; but I should say that for a breech-loading piece it is desirable to secure all the reduction in weight safely to be obtained, and to so mount the gun wherever practicable that it shall have no recoil—a system proposed by me years ago, and already adopted for casemate guns and for ironclads, in some instances, by Krupp and others. A reduction of weight being made possible by the introduction of a new material, it is a point in favor of that metal. The introduction of aluminium bronze, and other alloys containing that curious metal, seems to promise important advance in the arts, and in none more so than in ordnance construction, if we may take the existing figures as indicative of what may confidently be expected of this alloy when it is attempted to use it on a large scale and in heavy ordnance.

If I may be permitted to judge from what I know and have ascertained from various sources, including the best authorities on metallurgical work, regarding the aluminium alloys, I should say that they are beyond doubt enormously more valuable for ordnance construction than any ordinary bronzes, and unapproached by any alloys, when properly made, except possibly by some of the phosphor bronzes; although I have sometimes found it possible to get extraordinarily high tenacity from the common bronzes by the use of good fluxes and great care in their manufacture, in the manner indicated at the end of Vol. II. of my Materials of Engineering (Non-ferrous Metals and Alloys). As is seen also in the chapter on the "Kalchoids," it is possible to find metals which will alloy in such proportions as to give tenacities approaching those of the ordnance steels and yet with some ductility; but it requires very nice mixture and manipulation to secure such alloys with certainty and safety.

Much has been expected, for many years, from the aluminium bronzes; but their high cost has hitherto prevented their use, and has even prevented any extended investigation of their valuable properties for such everyday purposes as are now proposed by the Messrs. Cowles. But enough has been learned to prove their extraordinary value for many uses. That we shall in some directions be disappointed in our hope of securing remarkable results from them is most likely. It can hardly be supposed that they will prove universally applicable in the arts; but we may certainly, from what we know of them, expect to get good ordnance metals from among these alloys. It was many years ago discovered that some of these alloys were vastly superior to common bronzes in every way, and that they had a strength and a ductility combined that at once promised very extensive useful application. Their exceptional stiffness was one of the first properties noted. The ease of working as compared with some of the more common metals is an important characteristic, and the permanence of the polished surfaces in air, or when exposed to gases, is more than an ornamental attribute. This characteristic has peculiar value in ordnance, and especially should it prove to be thoroughly practicable to make rifled ordnance of it. The ability to withstand the degenerative influences of recasting, discovered by the Messrs. Cowles, is an exceedingly important feature of these alloys; and if it should prove feasible to employ the Dean process of internal hardening and drawing to increase their value, and should this method, which has been found to have such extraordinary value when applied in the construction of common bronze guns, also prove to be equally effective here, the conclusion must be admitted that aluminium bronze is one of the most promising of all the materials which have yet been introduced and proposed for this kind of work. It possesses, in the best mixtures, a tenacity and ductility, an elastic resistance and resilience rivalling the best ordnance steels; its best qualities exhibit sufficient hardness to insure good wearing power, and it can be cast and recast in heavy masses without injury. It is easily worked; is probably capable of profiting by the Dean process, and, if the difference in the coefficient of expansion should not prove to be too great, may probably, when considered necessary, be steel lined. It thus would seem to possess all the desiderata of good ordnance metals.

A gun composed of a metal approaching 100,000 pounds tenacity, and above 60,000 pounds elastic limit, having measurable extension and ductility, hard, unoxidizable, cheap in construction, and durable under wear, would seem to promise well. It certainly would justify the most careful and extended investigation on the part of ordnance officers.

Lieutenant M. E. HALL, U. S. N.—*Mr. Chairman and Gentlemen:*—Mr. Cowles has so fully and ably set forth the merits and advantages of aluminium bronze as a gun metal that I merely wish to state that I coincide in the views he has expressed, and to add my experience and observation of the workings of the aluminium alloys.

Two years ago my investigations into a suitable metal for a torpedo flask led me to inquire into their merits. At that time small quantities of metal were produced in an experimental furnace, and some of the tin-copper-silicon alloys

promised excellent results, the tests showing great strength and ductility. I selected a grade of silicon bronze that in small castings had developed a tensile strength of 74,000 pounds and an elongation of 18 per cent. A flask was cast at the Washington Navy Yard, and a test bar from it showed a tensile strength of but 25,000 pounds, with scarcely any elongation. Upon examining the fracture there were decided evidences of liquation, and upon further investigation I became convinced that this would occur in all large castings of tin bronze, unless chill molds were used to effect rapid cooling.

A representative of the Cowles Company came to Washington to inquire into this unsatisfactory result. He stated that later experiments at Cleveland tended to confirm that made at the Navy Yard. Being satisfied that silicon bronze would not answer my purpose, we cast some test pieces of A_1 aluminium bronze, which developed the following properties:

Dimensions. Length.	Diam.	Weight applied.	Weight per square in. on orig. section.	Elastic limit.	Elongation. Per cent.	Reduction of area, per cent.
2.0"	.500	22,485	114,514	...	0.45	0.00
2.0"	.501	21,650	109,823	79,894	0.05	2.39

These results were so remarkable that I expressed at the time my belief that the metal would make an excellent gun, if it retained its strength in large castings and under a moderate heat. Further inquiry into the properties of the metal showed that it might not stand the high heat that was an accompaniment of the power I purposed using at that time, and for the time I abandoned its use.

Not being able to obtain a steel flask, after having spent much time and some money in the attempt, I was obliged to change my plans and avoid the great heat required by the former design. During this time I had experimented upon castings of steel, phosphor bronze, and the aluminium alloys, and finding the latter superior in strength as well as ductility, and also far more free from flaws and blow holes, I decided upon the use of aluminium brass, having a strength of 87,000 pounds per square inch. Mr. Cowles and I made various experimental tests, some of which he has narrated. I satisfied myself that even in green sand castings there was no liquation with aluminium bronze or aluminium brass; that they retained their strength in large castings; that aluminium bronze, remelted without the further addition of copper or aluminium, developed the same properties in the second castings, while under the same conditions aluminium brass deteriorated slightly in strength, unless a small percentage of zinc were added. Contrary to expectation, aluminium bronze (A_1 grade) was found to be practically as strong when heated to 400° as when at normal temperature. At their works I saw a number of aluminium bronze cylinders 6 feet long and 15 inches in diameter and 2 inches thick, some of which were turned down to ½ inch in thickness during my stay, and in no case did I see a single flaw after the surface scale was cut under. Of the thirty-three castings made for me, all were good save one, and that gave evidence of having been poured in a damp mold.

It has been the belief in some quarters that the exceptional strength of these alloys was owing to the small castings that test pieces were taken from in the

earlier uses of the metal, but that failure would follow in the attempt to make large castings. My observation leads me to the belief that large castings can be made that will prove fully as satisfactory as those made from any metal, and surpass them all in either strength or ductility.

In the lathe under the tool, A_1 bronze and the higher grades of aluminium brass show properties similar to machinery steel, while the lower grades resemble wrought iron, the turnings coming off in long tight curls. The file makes but little impression on the higher grades of these metals. From this fact it would appear that the fears of abrasion in the bore of a gun when made of other metals than steel, so often expressed by advocates of the built-up gun, are not well founded when applied to these alloys.

One of our eminent authorities (Captain Birnie, U. S. A.), in comparing built-up with solid cast-steel guns, remarks: "We have now reached a stage of gun construction where we are not prepared to accept haphazard affairs. It will be necessary first to establish that the operation of producing initial tension in a steel cast gun can be conducted with certainty, and can be regulated to a proper degree by the manufacturer. When this has been shown, and good sound guns so made, with metal of the requisite physical properties, have been produced, the steel cast gun will have a respectable standing." In the aluminium alloys, possessing enormous strength and great ductility, ranging in the bronzes from 114,000 pounds tensile strength and 5 per cent elongation, to 90,000 pounds and 10 per cent, and to 72,000 pounds and 47 per cent, and in the Hercules metal, varying from 80,000 to 100,000 tensile strength and 20 to 30 per cent elongation, there can be found gun metals whose physical properties would suit the most conservative gunmaker, and whose qualities would satisfy the most arduous conditions of service. With interior cooling and heated molds the initial stress can be regulated, and every condition required for perfect cast guns can be readily fulfilled. Such a gun would give us a distinctive and superior type of ordnance.

In view of the remarkable properties possessed by these metals and the advantages of construction, it would be well to cast two service guns of aluminium alloys and of the types proposed, and to test them thoroughly in competition with built-up guns of the same weight and calibre.

It is to be hoped that the use of these metals for gun construction will be thoroughly prosecuted by our Government, that in future years we may not be called upon to adopt them, as we have done with the Eastman breech block and the Hotchkiss gun, as products of American ingenuity developed by more progressive governments abroad.

MR. EDWARD W. VERY.*—*Mr. Chairman and Gentlemen*:—I have read carefully the advance copy of Mr. Cowles' paper on "Aluminium Bronze for Heavy Guns," and in compliance with your request, venture to express my opinions and criticisms with regard to it.

In so far as the comparative adaptability of aluminium bronze to gun construction is concerned I can offer no positive opinions, and I regret that Mr.

* Of the Hotchkiss Ordnance Co., formerly Lieutenant, U. S. Navy.

Cowles should not have favored us with more complete information concerning the technology of this alloy; for, from what little I have been able to ascertain with regard to the possibilities of development of its physical characteristics, I am inclined to believe that in so far as the strength, reliability, and economy of casting are concerned it presents features of promise.

I think that I am right in saying that the gist of Mr. Cowles' remarks may be expressed as follows: that gun construction can be simplified and improved by casting aluminium bronze, using the Rodman process of cooling, and supplementing the work by mandreling the bore. There is nothing whatever irrational in his proposed development, and any good artillery engineer would say that this method has chances of success. None would *prophesy* success, for the reason that there are uncertainties and difficulties to be met with in practice of a very serious nature; so serious, in fact, that they have heretofore proved too great for the success of those who have tried to follow this line of development.

I disagree most radically from the arguments that Mr. Cowles has made in support of his proposed development, for I am certain that not only do they do more harm than good to his case, but that if he attempts to follow out the ideas as expressed in his paper he will certainly come to grief. I shall criticise these arguments severely, and I trust that Mr. Cowles will accept my strictures in good part. He is not an artillery engineer, and is not familiar with the difficulties of practical artillery engineering. I am an artillery engineer, and I beg to call to his attention that I am not a self-styled one through the grace of some invention connected with gunnery, but regularly accredited as such from study of the science, constant practice in all the branches connected with it, and successful practice at that. It is strictly and constantly as an artillery engineer that I earn my bread and butter. I do not mean to imply by this that I am endowed with any grace of infallibility, but simply that in any discussion upon points of artillery engineering I have an advantage over those who have no practical experience in the science, and of those who, on account of a successful mechanical invention, have come to be considered authorities upon the whole subject.

Mr. Cowles makes his principal mistake in failing to distinguish clearly between principle and practice as exemplified in existing gun construction, and I do not hold him in the slightest degree responsible for the error, for exactly this mistake seems to control the majority of the ideas prevalent throughout the United States concerning gun construction. As an instance, he goes at length into the question of the inherent weakness of built-up guns, and calls your attention to the great advantages presented in the Rodman and the Uchatius processes, without bearing in mind sufficiently, if at all, that these processes are simply *practices* by which it is attempted to fulfill economically a single fundamental principle which is as firmly established as the laws of gravity or the sphericity of the earth, and over which physicists have long since ceased to argue.

Whether you produce a gun body by Rodman cooling, by Uchatius mandreling, by wire winding, or by hoop shrinking, you are simply trying to get

as a result a "cylinder of equal resistance," and if any one wants to know what that is they simply have to refer to any text book of Applied Mechanics. A naval cadet in the second class can define it readily enough. Any one of these processes is superior to another only in the measure and the economy with which it fulfills the requirements.

Now, right here I wish time to make a statement of plain self-evident facts. It is the universal practice throughout the world to build up heavy guns by hoop shrinking. Not only do the Government arsenals follow this method, but also the great private establishments, such as Krupp and Armstrong. Let us look farther now, and I will point out the Government of Holland, where for over twenty years the most strenuous exertions have been made to adapt casting and mandreling to large guns. Examine the work of General Rosset, backed by the Treasury of the Italian Government, and carried to the extreme of trying to get a successful seventeen-inch gun body by the Rodman process with cast iron. On the other side, I call attention to the great works of Gruson & Co., in Germany, far and away the best equipped works in the world for casting, and second to them the Seraing Works in Belgium. Neither of these works will have anything to do with the production of cast guns, although gun manufacture lies directly in their line of work. Now, is it not plainly evident that if Germany is forced to hold to Krupp's monopoly, and if Italy, Holland, and Belgium are forced to go abroad for their guns and thus violate one of the first principles of military security—is it not a fair evidence that in actual existing gun making, hoop shrinking is more reliable and economical than casting with the Rodman process? Turn to Austria, where General Uchatius backed by the Austrian Treasury, fairly went crazy in his strenuous efforts to develop the system. Austria's guns are still built by hoop shrinking. Look again, in our country, at the efforts made and still making by Dr. Woodbridge, with the aid of the Government, and at the independent efforts of Sir William Armstrong & Co. with wire winding, and remember that in the latter case wire winding and hoop shrinking are competing in the same shops. I will not cite Longridge in this connection, because he has had to fight the Government in the matter of principle, nor Schultz, who died before he could carry practice far enough. In spite of these strenuous efforts, hoop shrinking is ahead.

Now, mark my demonstration: not one of these abortive efforts has failed from an error in principle, nor have any of them caused a single artillery engineer to disbelieve in their inherent soundness; but, as I stated at the start, these four practices aim at the fulfillment of a single principle, and practically, hoop shrinking has so far given the best and *most economical* results.

There is no use in the lecturer or any one else making the attempt to prove the whole world wrong. It is not a case wherein Galileo and the Church can be cited, for as a matter of principle the world is on Mr. Cowles' side, and they wish him success in following up his line of development; but when such an expert as Rosset burns his fingers, and such a firm as Gruson & Co. stand by and shake their heads, it behooves the rest of us to "go slow." I can assure Mr. Cowles from practical experience—and I am fairly familiar with about every

big gun factory in the world through visiting and examining them, and I have had direct dealings and personal interviews with almost every War and Navy Department in the world—that there is not a single one that belittles or denies the practical difficulties or obstructions to successful gun making where shrinking is the method employed—not a single department, either public or private, that would not hail with joy any amelioration of their difficulties. To government arsenals it means greater security and less work; to private establishments it means greater dividends. Surely it cannot be believed that private manufacturers are so fond of the built-up system that they will continue, without a murmur, to make a sheer sacrifice of 40 per cent of the metal in every large tube and jacket forging, or to true up a cylinder of four feet diameter by twenty feet in length to a half a thousandth of an inch for shrinkage, or to sink a hundred thousand dollars in a tempering plant that is of absolutely no value at all commercially outside of gun work. No, no! We must first of all distinctly recognize that, even handicapped with all its difficulties, hoop shrinking has so far given the most satisfactory results, both as to the resulting gun and as to dollars and cents involved. There is no fault at all in the principle involved in casting, but the trouble has been in carrying out the principle.

The lecturer goes into details concerning the bad points of built-up guns. Let us look for a while at the points which he makes. One of his first points in connection with the ideal gun is, that it "must be of one piece in order to act like a great spring." Now, let us look this great spring business square in the face; let us go to any railroad in this broad land and look at the great springs upon which our locomotives and passenger cars are mounted. We shall find them all "wagon springs." True, we shall find also spirals on the bogies, but they are secondary springs; the *great* springs are all "wagon springs," which are certainly not of one piece. Mr. Cowles has made a serious mistake not only in his illustration, but also in his whole conception of the spring as associated with gun-wall resistance. There *is* a connection, but he has missed it.

A little farther along appears an assertion with regard to the distance that a metal will stretch within the limit of elasticity. Why, I ask, go to such pains to lay down a law and illustrate it, on the subject of the "coefficient of elasticity," that every engineer who works in metals, be he an artillery specialist or any other, never fails to take fully into account? This very feature is one of the banes of existence of any artillery engineer who designs a built-up gun, and it will perhaps be a surprise to the lecturer to know that this same coefficient of elasticity will be harder to handle in casting than in shrinking. It is one of those family ghosts that are far better off shut up from public gaze. At least, get acquainted with its tricks before handling it.

I do not wish to be considered captious in my criticisms. If I state that a proposition of Mr. Cowles is either not at all new or is unimportant, I do so not with any idea of stating "what I know about guns," but to convince Mr. Cowles that he proposes to embark in a line of development not a single point of which can either be slurred over or misunderstood. Let me take one of his points and explain my meaning in this respect. Mr. Cowles defines an

ideal gun as one "of minimum weight and simplest construction." Here is a case where his enthusiasm over his alloy and unfamiliarity with the demands have led him into a path which, although of slight importance now at his start, might lead to total disaster. There are undoubtedly circumstances where light weight of gun is an essential, but the great main rule, founded upon the well established principles of dynamics, is to make your gun heavy. I do not mean that you must pile on tons weight, but, if you have a gun and carriage anywhere and under any conditions that together weigh, let us say ten tons, if you could have all the weight in the gun and none at all in the carriage you would touch the ideal. Examine this assertion on the other side and the explanation is self-evident. Suppose that your gun was of the same weight as your projectile, what, pray, would become of your carriage?

Now I assume that since the alloy has a percentage of aluminium, it has a light specific gravity, and Mr. Cowles assumes this to be an advantage. As a matter of fact, I should say that the difference of weight realized in a well built gun would not be of much consideration one way or another; but if Mr. Cowles starts off on the light-gun track, the artillery engineer that has to get up the carriage to hold his gun will kick as viciously as the gun itself against this violation of a mechanical law.

The next point which I shall attack is a very serious one indeed. I quote from the article: "In this brief article I need not refer to the many recorded failures of steel guns, and the known instances of cast-iron guns surpassing steel in endurance and approaching it in destructive power." I would ask if he thinks that the whole artillery world has gone stark staring mad in throwing out cast iron in place of steel—that governments would deliberately pay three times as much for a steel gun when a cast-iron one was better, or that private firms would content themselves with half the profits by working in steel that they could make on cast iron.

If it is not enough that practice should go all one way, I ask if Mr. Cowles will accept the logical deductions from his argument. If there is anything inherent in cast iron that makes it a better metal than steel, then aluminium bronze is inferior to cast iron, since in characteristics it lies nearer steel than cast iron. If, on the other hand, steel as a metal is all right, but it is the process of building that is at fault, then I ask him what he has to say about steel cast guns cooled by the Rodman process such as are about to be manufactured in this country. His argument as made is clearly and fairly against his own metal, but fortunately the argument and the foundation statement are both wrong. If Mr. Cowles proposes to accomplish anything with aluminium bronze, my advice is for him to drop cast iron at once and forever. It is a worse enemy to him than steel.

Let me now take up the laws that are laid down as to the physical requirements of a gun metal. "The metal around the bore of the gun must have as high an elastic limit as attainable; the distance the metal will stretch within its elastic limit must be as great as possible; the metal should be as ductile as possible." If Mr. Cowles will keep these three points strictly together, in the same metal, his idea is all right, although I do not think that it is expressed so

as to give what is really meant. I wish to point out first some metal indications that are valuable in themselves and certainly should not be lost sight of.

1. What metal can be made to develop the highest known limit of elasticity? Steel.

2. What metal can be made to develop the highest known coefficient of elasticity? Steel.

3. What metal can be made to develop the highest known ductility? Steel.

I refer Mr. Cowles to Jean's work on steel manufacture for corroboration of these answers. This work has no special artillery significance, and I believe is considered about the most complete and exact compendium on steel extant.

Now, I do not assert that it follows naturally that because steel may be made to develop the extremes of these qualities, it may also develop all three at once better than anything else, but simply that it is rational to expect that chances would be in favor of reaching the desideratum by some combination of steel. What I should like an explanation of, however, is why, after laying down these laws so positively, he deliberately sets to work to show that cast-iron guns, which have a very minimum of all three qualities, are superior to steel guns. Is it on account of the fact of the casting? Then I cannot see why, in his table quoted from a report on heavy ordnance, he should have taken but four guns, not one of which fills the bill.

1. The Rosset gun, of which I can readily produce the undeniable evidence from Rosset's own pen that the main reliance for developing strength of cylinder was in the steel hoop shrinking.

2. United States cast-iron gun lined with wrought iron. I can produce the written evidence of Sir Edward Palliser that the principle governing this construction was the same as that of the Uchatius mandreling, the cast iron playing a secondary part.

3. Italian cast-iron gun hooped with steel. This gun was built on the French system of construction, which is exactly the same in principle as is followed in all steel built-up guns.

4. Converted cast-iron Rodman rifle. This was a gun converted by shrinking a cast-iron body on a steel tube—a clear built-up gun.

Having cited these cases, Mr. Cowles proceeds to the deduction that they gave greater efficiency because there was a certain percentage in their favor when we come to compare average pressures used with tensile strength of metal. The percentage thus found has no value whatever. What law can be found in the whole range of physics that will permit one metal safely to stand strains beyond the tensile strength of the metal, and that will forbid another metal doing the same thing? Does Mr. Cowles propose to abolish from engineering that item called "factor of safety," or does he assume that however necessary the item may be for railway and bridge building, it may be left out of account in gun building? If the elastic strength of a cast-iron gun is twelve tons, and that of a steel gun is twenty-eight tons, we have at once the percentage of strength. The pressure that people choose to submit them to is another thing.

Mr. Cowles has been told that the Krupp Company will only guarantee their "built-up" steel guns to stand seventy-five charges. He has been entirely

misinformed. Krupp or Armstrong either will guarantee their guns for a thousand or more rounds in so far as strength of gun is concerned. I cannot assert, but I feel quite certain, that there are many steel built-up guns (I use the word, many, advisedly) that have turned three thousand rounds; I know of one gun in this country. In the Hotchkiss shops at Paris there is a gun (a 3.2 inch army gun), light, it is true, but it is a steel built-up gun, and the maximum chamber pressures used in firing average about 15 tons per square inch. That gun has stood about 2800 rounds, and is in use constantly in testing ammunition. I frequently have to stand up behind that gun and fire it from the shoulder, and I hope to get many shots from it yet. I am confident that it will not be condemned until the rifling is all worn out of it.

Mr. Cowles gives an estimate of cost of gun building, in which he starts with an assertion of the cost of steel guns in Europe. I suppose that he has taken the figures from *selling* prices in Europe. Certainly he does not mean to tell us that he knows what it costs Whitworth or Krupp to build a gun; that is a trade secret. He compares this price with the cost of French and Italian cast-iron guns. These being government prices, are *cost* prices. Now, on top of a selling price he adds 40 per cent for American cost prices, and then makes deductions for the price of aluminium bronze. Mr. Cowles, I am certain, is sincere in his estimate, but I can give him a few points, I think.

In the first place, he can find out exactly how much it costs to build a steel heavy gun in this country by asking at the Naval Bureau of Ordnance. I have not asked, but if the average price is as high as 45 cents per pound I am very much mistaken. As for the 40 per cent premium on American labor, that is absurd. Guns can be built, are being built, and I am in charge of the building, that will cost nothing near that amount more than they would cost in Europe, and I pay very high prices comparatively for material.

I close with an answer to Mr. Cowles' last question: "Would it not be well for our Government to appropriate ample funds to investigate this promising field, and learn wherein these alloys can be applied in the construction of ordnance and armor?"

I answer most emphatically, no—not while an American has the gumption to stand up on his own feet and do his own work. What! are we civilian artillery people to turn beggars and go chasing after Congress to give us money to work out our ideas? Is this the way that Edison does? Did our locomotives, our reapers, our sewing machines, our Winchester rifles, our very reputation as inventors come from the Congressional nursing? By no means. Let Congress say whether it wants a defense for the country or not. That is the business of Congress. Let the military and naval departments say what are needed for defenses. That is their business. Let me compete fairly, squarely, and unaided, as I demand that others shall, to supply the material that is demanded by those military and naval departments. That is my business. It is a business conducted on the broad free American plan. I do not say this in enmity to Mr. Cowles' system. I do say, however, that whatever amount is given him must in like manner be given to Wiard, to Haskell, to Hunt, to me, to Gatling, to Berdan, to Zalinski, to any one and every one who has a plausible

scheme for the defense of the country. Give to all or give to none. I say give to none. Mr. Cowles may receive government aid in development, and if he does, I predict for him the same measure of success for his system that has followed like donations. Nothing so quickly generates dry rot in the brains that work. I know what it is, for I have worked in the service with my salary ensured, and I am working now out of the service with my income dependent on my work. No one ever loved the service more than I did, or felt more aptitude for a sailor's profession. I have worked harder and longer since I left than I did while there, and never for a moment have I regretted leaving the Navy; for I never knew there what I could accomplish if I was pushed to it. One of these days, when I get too old to do anything, I may want to be led to the trough to feed, but not yet. I prefer to stick to artillery engineering, and when casting, or wire winding, or mandreling get ahead of hoop shrinking, I will be there with it. I wish Mr. Cowles all success, and, as I said at the start, there is nothing irrational in his proposed development; but before he starts I beg him to make up his mind to go slow, go sure, and above all, go it alone. If he does otherwise, he will not only fail, but will drop to that unenviable condition so well known about the halls of Congress, of "a man with a grievance."

Lieutenant ALBERT GLEAVES.*—*Mr. Chairman and Gentlemen:*—The arguments that the lecturer uses against steel built-up guns, such as the impossibility of learning the exact elasticity of great masses of metal, variations in their elasticity, variations in their contraction during cooling, apply with equal force to cast guns of heavy calibres, whether of steel or aluminium bronze.

In referring to the present methods of gun construction on the principles of initial tension and varying elasticity, it is stated that "to accomplish this satisfactorily by building up a gun is generally conceded to be impossible," and that it calls for such nicety of work, "practical men consider it impossible." The magnificent steel guns that are yearly turned out at Essen, Woolwich, Abouchoff, and by the firms in France, are the most conclusive answer possible to these statements, and the list of practical men and distinguished artillerists who build and advocate them includes names too well known to require mention. But it will not be necessary for the lecturer to leave the United States in order to see a satisfactory built-up all-steel gun, for within a short distance of this hall are built-up steel guns that have been proved to be satisfactory in every respect. Mr. Longridge, the eminent advocate of wire-wound guns, opposes built-up steel guns, but the substitute he proposes will, by his own calculations, be inferior to the service gun; for the 5-ton wire-wound gun recently ordered on his design is expected to have, with a 100-pound shot, an initial velocity of only 1870 feet, while the corresponding steel gun with the same weight of projectile gives 2000 feet. Advocates of the steel gun do not claim that it is the ideal gun, "in which the initial tensions of the metal vary from the centre outwards, corresponding exactly with the variations of the strain thrown upon the different parts at the moment of explosion," but they do claim

* On duty at the Naval Ordnance Proving Ground, Annapolis, Md.

that this is more nearly accomplished, and with fewer accompanying evils, than by any other method of fabrication.

The lecturer suggests two methods for the fabrication of aluminium bronze guns, namely, first, upon Rodman principles, and second, upon those of Uchatius. In regard to the first, an Italian writer in 1882 said, in speaking of the splendid results obtained by the Rosset guns (cast on Rodman's plan and hooped with steel), "in heavier guns we cannot be certain of obtaining homogeneity throughout thickness of the metal," and "can we hope with this system not to fall behind? Will it not be more prudent to abandon entirely the use of iron, and seek in steel a strength that iron cannot give, and which the present condition of artillery demands?"

Again, the Austrian artillery, which is quoted as having used exclusively since 1873 the Uchatius method, is composed, according to Brassey (January, 1886), of ten types of Krupp guns, two of Armstrong, and three of Uchatius, the calibres of the latter being 5".87, 3".43, and 2".87. It has been stated in England that attempts to fabricate on this principle the large tubes required for heavy natures have been unsuccessful; moreover, the method was abandoned in Austria in 1881 on the death of General Uchatius, and the Krupp steel gun adopted.

The difficulties in casting guns increase rapidly with the calibre, and as yet have not been overcome. The only proof that it is possible to cast a successful high-power gun is the actual accomplishment of the fact—all else is theory.

Neither the powder pressures alone nor the tensile strength of the metal in guns is a criterion of their efficiency. As Major Mackinlay remarks, in his excellent Text-book on Gunnery, the best measure of the efficiency of a gun is the amount of work producible with safety per ton weight of gun, and on this basis, with the data compiled by the lecturer, let us compare the much abused steel gun with the cast-iron gun.

	Cal. inches.	WV. tons.	Projectile. pounds.	I. V. feet.	Work per ton weight of gun.
	Steel Guns.				
(*a*)	15.75	71	1711	1702	484.4
	13.97	51	1155	1642	423.5
	12.	36	664	1517	294.7
(*b*)	15.75	71	1762	1695	495.
	Cast-Iron Guns.				
(*a'*)	18.	87	2200	1378	333.5
	12.6	38	770	1492	313.2
	12.25	40	700	1485	268.
	17.72	100	2204	1512	349.9
	11.	24.3	543	1352	283.3

From this we see that the steel gun (*a*) of 71 tons, weighing 16 tons less than the cast-iron gun (*a'*), does 151 feet tons per weight of gun more, which represents an increase of 45 per cent in efficiency, and the steel gun (*b*) is in like manner 41 per cent more efficient than the 100-ton cast-iron gun which weighs

29 tons more. In other words, with a strength of metal three times as great we have increase in efficiency of 41 per cent to 45 per cent, instead of 25 per cent when the guns are improperly compared as to their tensile strength and powder pressures alone. Even if these cast-iron guns did the same amount of work as the steel guns with which they are compared, the great difference in weight would be a most important factor in favor of the steel guns for naval artillery. Moreover, in speaking of the pressures in cast-iron guns, the lecturer does not follow out his own distinction between cast-iron guns tubed or banded, and homogeneous guns. As a matter of fact, the pressure in homogeneous cast-iron guns varies from about 8 tons in the IX-inch S. B. to 11.3 in the XV-inch.

Let us now consider the relative endurance of cast and built-up guns. The life of our old cast-iron guns is estimated to be 1000 rounds, but cast guns have been fired as many as 3000 rounds. The endurance of steel guns is perhaps not so great, but, as has been shown, steel guns do much more work and are therefore better. Colonel Maitland mentions a 6-inch gun that was fired 1800 times, and an 8-inch 12-ton gun that was fired 67 times "between breakfast and lunch." An 11-inch B. L. which was found to be unserviceable from erosion after firing 95 rounds, was lined, and up to February, 1887, had fired 239 rounds and still remained serviceable. In 1886 trials were made at Gâvre to determine the life of steel guns, with the following results, which are taken from the recent N. I. office publications:

2″.56 steel B. L. R. This gun was fired in all 2081 times, and although the erosions were so great that the lands were almost entirely gone, the resistance or strength of the piece was adjudged to be as good as when new.

3″.54 steel B. L. R. Fired 900 times.

3″.9 steel B. L. R. Fired 1295 times; owing to great erosions at 1115th round the life of this piece was set at 1000.

5″.5 steel B. L. R. Fired 424 times and the life of the gun placed at 400.

6″.3 steel B. L. R. Fired 595 times, 539 rounds being with service charges. It was not until after the 338th round that any change could be observed in the bore.

"Guns of this character can only be regarded as unfit for service in war after they have lost this accuracy, or when they are so much weakened that a rupture of the piece may occur." It is to be noted "that the power to resist rupture was never impaired beyond a point of safety, and that relining the bore would have made the guns almost equal to new ones."

The guarantee of the Krupp gun to be only 75 rounds, standing alone as it does in the lecture, is apt to be misleading. It probably means that the gun is guaranteed to stand 75 rounds before it becomes necessary to reline the tube.

That aluminium bronze is estimated to cost 16 cents per pound less than steel is not a particularly weighty argument in its favor, for that gun is the cheapest *always* which is the best, regardless of its intrinsic value.

No doubt it would add much to the appearance of a man-of-war to be armed with guns that rust does not corrupt and that have the lustre of gold, but so would purple sails and silver masts. However, the great question is one of efficiency; and if guns cast of aluminium bronze are better than steel guns,

by all means let us have them, but as at present these guns exist only on paper, it is simply a question of theory against practice. If the lecturer will produce a gun cast of aluminium bronze which will stand the prescribed test and give better results than built-up steel guns, then ordnance officers will be as eager to defend it as they now are to uphold the steel guns which have so far surpassed all others.

Ensign J. H. GLENNON.*—*Mr. Chairman and Gentlemen:*—Looking over this paper in some detail, we come first to the physical properties that a metal should possess in order to make a good gun metal. The lecturer states first that the metal around the bore should have as high an elastic limit as is attainable. This, of course, is true so long as we use a metal that is safe in other particulars. It is the reason for using medium steel in preference to low steel, wrought or cast iron, or aluminium bronze, if we consider what is really already attained with that metal as shown by the paper before the Institute. Secondly, he says the distance the metal should stretch within the elastic limit should be as great as possible. The reason for this is not evident, nor does the illustration given by the lecturer really prove anything. There is a limit to the allowable stretch. A metal that would extend like India-rubber, for example, would not do at all. Nearly all the work of the powder would be wasted in stretching the gun; and in two guns, the elastic extension of one being twice that of the other for the same pressure, there would be just *twice* the work, useless work, expended on the first that there would be on the second. This work would, of course, lessen that done on the projectile. In any gun, however, this quantity would be small; there would not be enough extension to lessen the pressure materially, and we would find that the maximum pressures two guns could stand, supposing their elastic strengths equal, would be precisely the same, and entirely independent of the elastic extension.

The lecturer says, thirdly, the metal of the gun should be as ductile as possible. There is no one thing more written about in discussions on guns than ductility. The lecturer believes in making a gun a spring. Of what use is ductility in a spring, as a spring? *No* ductility in a gun metal would be undesirable; but excessive ductility is not needed. If a higher elastic limit can be attained by stretching a metal somewhat, provided that we do not materially weaken it to resist compression, ductility can be brought into play. We would permanently stretch the metal, and get rid thereby of some of the ductility. But after a gun is down to its finished dimensions, it is a bad thing for it to have such a low elastic strength as will bring its ductility into play at all. If the gun, as it will if properly constructed, will extend during firing and afterwards return to its original dimensions, the bore which is cylindrical at first will remain so. If not, parts unequally strained will have different sizes and shapes. A gun is unequally strained in its different parts. The bore, after firing, if ductility is brought into play, will therefore necessarily be irregular. This in itself will cause irregular strains in future firings, and therefore other irregularities, which must be removed in some way or else the gun will burst;

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if removed, we will have a weaker gun than we had originally, and can go ahead and repeat the process until we are sure we have no reserve ductility to count upon, when it would be a wise precaution to stop firing altogether. A gun may be so built, as is the Navy 8-inch M. L. R., that it is really not finished until after some of the ductility of the inner tube is brought into play; in the particular case cited it is *necessary*, in order to set the tube firmly in its cast-iron casing. Of what further use is the great reserve ductility of the wrought iron, which cannot be brought into play at all except by bursting the outer cast-iron body? A little further on, the lecturer speaks of the value of cast iron as a cannon metal. Whatever other properties it may have, it certainly does not possess much ductility. On the other hand, wrought iron does possess great ductility. In guns, however, it has been *fully* tried; and found wanting, if we can judge anything from the action of Great Britain in this regard.

With respect to the fourth point, hardness, steel with a high elastic limit *is* hard, and naturally, with steel guns, we hear little talk about this particular property.

To realize the principle of initial tensions *exactly* is the mechanical impossibility. That it is realized *satisfactorily* is proved by the fact that all gun-makers, private firms whose pockets are affected by failures in their guns, adhere to it. It is impossible to realize the full tensile strength of the metal in the form of pressure without permanently deforming the gun, where we use any metal of which the tensile is double the elastic strength, no matter how the gun is put together; unless the elastic limit for compression is very much greater than that for extension. The lecturer says nothing about the elastic limit for compression of aluminium bronze in its original form, not to speak of what it is after mandreling. (By mandreling the gun he is bound to stretch the metal more than he compresses it, unless the outside is held in some way.)

The $\frac{1}{1000}$-inch tension mentioned by the lecturer is tension per inch. In a ring 17 inches in diameter this would be .027-inch extension for the circumference, and would be very quickly noticed.

In steel built-up guns the shrinkages can be calculated for the minimum value allowed of the elastic strength of metal. The modulus of elasticity for different steels being practically constant, the gun will certainly be as strong as it is calculated to be.

It would certainly be hard to say what would be the effect of vibration in a built-up gun, or in any gun, when we remember that the blow is not delivered at a point, but along the whole bore successively. Nor does the fact of vibration seem to have much bearing on built-up guns and gun-bursting, as all the recent guns that have failed have done so at points where the guns were not built up.

The lecturer apparently thinks that cast-iron guns with steel or wrought-iron tubes are not built up. They are, however, just as pure examples of the built-up gun as if both parts were steel and one shrunk on the other; the difference is in the way of the building. In the one, the outer tube jacket or hoop is shrunk on; in the other, the inner tube is forced out.

A comparison in the efficiency of guns can easily be instituted from the guns at present in the naval service. Take the two 8-inch guns, the one all

steel, the other cast-iron body with wrought-iron tube. The first has a muzzle velocity of 2000 feet, the latter 1450 (however, not realized in practice); the projectile of the former weighs 250 pounds, of the latter 180 pounds; penetration of the former in wrought iron at least twice that of the latter; the extreme range at least double; the accuracy in firing in a still greater ratio, and the muzzle energies 25 to 10.

General Uchatius was modest, and started with a tube of 43,000 pounds tensile strength, 6000 pounds elastic strength, and by mandreling raised the elastic strength of metal next the bore to 15,000 pounds, or about one-third the original tensile strength of the metal. The lecturer, by mandreling, proposes to raise the elastic strength of the metal next the bore to the full original tensile strength of aluminium bronze. This is mere speculation. Nobody would accept it without experimental proof. Mandreling, by the way, is practised on steel tubes for guns. Why not start with steel of 60,000 pounds elastic strength at once, and raise it by a similar process (on paper) to 120,000 pounds? Or, to take a metal with very similar properties, why not use mild steel of 70,000 pounds tensile strength and 30,000 pounds elastic strength, with a percentage of ductility of 30 per cent, and raise its elastic limit? The elastic strength of the steel is the greater, and the other qualities are the same in the two metals. What is there in the process that would apply to the aluminium bronze and not to the steel?

One point more: bronze in guns has always been more or less affected by the heat of firing. The metals of the alloy show a tendency to separate, leaving the strength of the gun that due to the copper. The lecturer does not say much on this point. At each fire, the bore has to stand a temperature somewhere between 3000° and 4000° F. After a few rounds fired quickly, the outside would be too hot for the hand. The only experiment quoted in respect to the effect of heat on aluminium bronze is one in which the alloy, after standing over 100,000 pounds stress when cool, broke at 86,000 pounds when heated, having stood over 100,000 pounds when heated once before. Might not the developed weakness have been due to reheating or over-heating, though the temperature was only 400° F.?

In conclusion, if a steel gun shows wear and tear in practice, we have always the option of falling back on the low charges, pressures, and velocities of cast or wrought-iron or bronze guns. The original cost of the gun being but a small fraction of the cost of the ship, and this in turn nothing in comparison with loss of prestige, or damage that might be incurred except for the ship, why should we not have the very best guns, granting that they do cost more?

We have very good guns now, as good for like calibres as any other nation. We want even better, and there are excellent chances for them in the very line now being pursued—guns made of steel, and of higher steel, even, than is now being used.

Mr. BIRDSILL HOLLY*:—In a gun, the one physical property, above all others, that the metal of its walls must possess is a high elastic limit. Truly, as

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Mr. Cowles says, this determines the pressure a gun will stand without distortion. Cast iron, wrought iron, the mild steel of commerce, and gun bronze have not this property; hence it would seem that the competition of the future must be between finer qualities of steel on the one hand, and some new and strong alloy on the other. The aluminium bronzes, having such high elastic limits, in addition to their other valuable qualities, appear to offer metals that will overcome the objections that have been raised against steel.

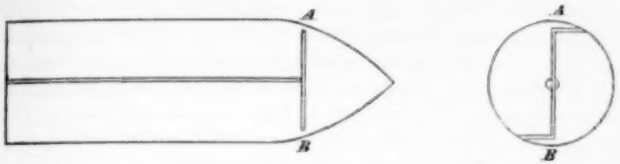
In order to utilize the total strength of the walls of a gun, these walls should, theoretically, consist of an infinite number of laminæ, put together with a gradual series of positive and negative compressions, of decreasing value from interior to exterior, so that under pressure of discharge the interior compressions will be converted into tensions, until one uniform strain is applied throughout. Notwithstanding this, all the work of making a gun has to be done by men, and men are sometimes careless. If they bore a part too large or too small, they will endeavor to have those parts go together before they are caught at it. I do not wish to say that the inspecting officer would be careless, but his opportunities are great.* If the tensions that are established in building up a gun are permanent, how is it that in the old Dahlgren guns the internal strains formed by external cooling during casting disappeared, through the effect of expansion and contraction with age and variations in temperature? If a gun is burst it may be broken into twenty parts; and making it in a dozen parts, to start with, is not mechanical. In such guns the continual dragging of one part on another, due to a difference of expansion, is not desirable. No two pieces of iron or steel expand equally. It would be best to abolish the steel tube in the solid guns. In order to accomplish this, radical improvements must be made in rifling. The accelerated twist, with studs to follow the groove, is not right, as only one stud can act in the groove at a time, thus concentrating the friction to too great a degree. With a uniform twist, and expanding soft metal on the projectile, at the moment of explosion this metal is being pressed forward with a pressure of from fifteen to twenty thousand pounds to the square inch, yet that part which is farthest forward is being held back by its friction against the walls. Under these conditions the soft metal flows like water and transmits this abnormal pressure to the wall of the gun, causing a great and uncalled-for friction, loss of energy, and abrasion.

If grooves must be used to give the rotation, the true mechanical method would be to have many of them. The friction is dependent upon the pressure, not upon the extent of surface. Too small an extent of surface will increase friction due to increased abrasion. The bore of the gun should be milled, and its cross section should resemble a fine-toothed gear wheel with the corners slightly rounded. The same miller should be used on the shot. Iron or steel working against hardened bronze would create less friction than if working against steel. In order to prevent the escape of gas through the windage, I would, with his consent, offer a method that was suggested by Lieutenant

* Alexander Holley's "Ordnance and Armor," p. 322. Cook's "Text-book on Naval Ordnance and Gunnery," p. 121.

M. E. Hall, U. S. N., which embodies the application of a principle that I patented about the year 1854. It is this: if a fluid be flowing under pressure through contracted orifices from one cavity to another, if there be but two cavities the pressure is reduced one-half in the second cavity, and if there be one hundred cavities it is reduced to one one-hundredth in the last cavity. Thus by cutting a large number of small grooves around an engine or pump piston I was enabled to prevent the passage of steam or water between it and the wall of the cylinder, although there would be a free opening from one side to the other. This principle is blind, and it once required much exertion on my part to prove it to engineers. It is now, however, very widely used in steam and hydraulic engineering. If our projectile, now, has grooves turned around it one-fourth of an inch apart, one-fourth of an inch wide and one-tenth of an inch deep, and in the bottom of its rifled grooves a series of shallow holes one-quarter of an inch apart be bored, no appreciable amount of gas can flow between it and the walls of the gun; this is assuming we have an ordinary loose fit between the projectile and gun. The same principle could be applied to prevent the escape of the gas through the vent. This grooving might increase the friction of the air during the flight of the projectile. This is ordinarily small, and experiment would determine whether the increase would prove a serious objection. By preventing the escape of gas through the windage, erosion forward of and at the seat of the projectile would be eliminated, the enlargement of the powder chamber would be lessened, as is always the case when a wad or sabot is not used. There would be no appreciable tendency toward the formation of the "indentation and enlargements," as they are dependent upon the unequal pressure of the gas, during its escape, upon the projectile, and with these defects absent greater accuracy would be obtained. It would seem as though there would still be a slightly greater pressure above the projectile than below and cause a downward pressure. In designing and working the Silsby rotary fire pump I learned that practically such is not the case, and that the grooves fully overcome this inequality. Further, the friction between a projectile and the walls of a gun is inappreciable, as far as the weight of the projectile is concerned, but comes either from the pressure of the powder gases being greater against one side of the projectile than the other, and this pressure being transmitted to the wall, or, in the case of an expanding projectile, the powder pressure being transmitted to the walls through the soft metal. In either of these cases the pressure is tremendous, and so are the friction, the wear, and the loss of energy, and the lessening of the life of the gun. The grooves would almost abolish these evils, and allow the ball to slide out with the same freedom that exists when it is driven home.

We still have a *rifled* gun which, to my mind, is not mechanical. Why rifle the gun at all? A small hole, passing longitudinally through an elongated projectile from its base to a point where its diameter has become slightly less, then branching at right angles to the axis and passing nearly to the surface, and again each branch turning at right angles, but in opposite directions, to the plane formed by the two former lines, and passing out of the projectile, would create vents for the gas which would give to the ball a rotary motion.



The size of the escaping orifice would determine the rapidity of rotation. The principle is the same as is used in the old Scotch motor, in which water is taken in at the centre, and ejected through pipes at tangency to a circle of revolution. The efficiency of this is as high as seventy-five per centum. The same would be true if our projectile is made into a rotary engine. It is an easy problem, knowing the diameter and weight of the projectile, and the average pressure of the powder gases for a given time, to determine the size of the small discharge pipes which should give the desired revolution. By this means the loss of energy due to obtaining the revolving motion second-handed, from the forward motion of the shot, would be saved, and the wearing of the rifling grooves would be obviated. There would be no weakening of the gun due to the grooves, and *smoothbore guns could be used as rifles.*

I make these suggestions to point out the possibility of overcoming difficulties that may arise in utilizing the best aluminium alloy as a gun metal. The object to be achieved is great. In order to find the best metal for guns, at the present time, it is worth while for our Government to exert every effort. There are many unknown alloys of aluminium that should be investigated. Through my residence being in Lockport I am familiar with some of the capabilities of the electric furnace and the wonderful properties of the aluminium alloys. The bronzes shrink more than cast iron. This is the case with all strong metals, and is easily overcome in casting. The absence of blow holes and the lower melting temperatures give to these alloys a great advantage over steel. The method of making alloys is such that stimulation such as Government patronage would give would greatly lessen their present reduced cost and enable them to enter into very general use. Were I to make a gun I would adopt the Parrott gun as a model, and make it with one reinforce, using such alloys of aluminium as would enable me to apply the principle of *varying elasticity*. The reinforce should be driven or screwed on by hydraulic pressure. The parts could in this case be cast with uniform dimensions. The Rodman method of casting would be used, keeping the outside of the mold heated.

The range of properties attainable in aluminium bronze is in its favor. While it was in the furnace I have seen it "doctored" and tested and almost any desired property obtained. It is uniform in its composition, and does not separate into a number of different alloys as does the tin bronze. We *know* that bronze guns are used and that they do not burst. I have long been of the opinion that if we could double the strength and elasticity of bronze, we would have a metal superior to steel for guns.

Mr. THOMAS D. WEST.*—*Mr. Chairman and Gentlemen:*—The able paper of Alfred H. Cowles upon the valuable properties of aluminium bronze for heavy guns, which I have been invited by the Institute to discuss, presents many practical and logical arguments in favor of this alloy as a structural material for devices of warfare.

At the meeting of the American Society of Mechanical Engineers in New York City last fall, I presented a paper advocating the casting of strong metals instead of forging them to shape. Some of the opinions there expressed are here repeated, and toleration asked for the same, as the ideas then advanced and the facts developed by my experience bear so directly upon the practicability of founding aluminium bronze in the fabrication of guns.

Our ability to melt the strongest metals, and form castings from them, presents a cheap method, having many advantages in the manufacture of ordnance and armor. There are, however, certain peculiarities inherent in most strong metals, which render the obtaining of *perfect*, *sound*, *clean* castings a much more difficult task than occurs in the manipulation of cast iron. These evils are due to *oxidation*, *shrinkage*, *contraction*, and to *shutting in of gas*. This latter may come from two causes, the delivery of air into the mold during pouring, or the liberation of gas from the metal during solidification. In casting steel the shutting in of the gas in the metal is our most serious difficulty.

The difficulties which beset the casting of aluminium bronze are, in some respects, similar to those which were encountered in casting steel. Much small work can be successfully cast by ordinary methods, but in peculiarly shaped, and in large bronze castings, other means and extra display of skill and judgment are required. In some strong metals there appears to be a "red shortness" or a degree of temperature after they become solidified at which they will be torn apart if they meet a very little resistance to their contraction, and the separation may be such as cannot be detected by the eye, but becomes known only when strains are brought upon the casting. To overcome this evil and to make allowances for sufficient freedom in contraction, different modes must be adopted to suit varying conditions and metals. Provision must be made for the incompressibility of cores, and parts forming the interior portions of castings, and for the resistance which flanges, etc., oppose to freedom of contraction of the mass. It is found that cores must be "rotten" and of a yielding character. This is obtained nicely by using rosin in coarse sand, and filling the core as full of cinders and large vent-holes as possible, and by avoiding as much as practicable core-rods or irons. The rosin causes the core, when heated, to become soft and yielding to the pressure of the contracting metal. By using this or green-sand cores we are able to surmount almost any difficulties that may arise in ordinary work from the evils of contraction, so far as resistance of cores is concerned, and similar provisions can be made in the case of flanges, etc. In casting large cylinders, such as a gun cast by the Rodman method, a hemp or hay rope wound around the barrel or cooling tube would prove an excellent yielding core.

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Like contraction, shrinkage is found seriously to interfere with the obtaining of perfect castings from all metals. In making steel castings much labor has to be expended in providing risers sufficient to feed them solid or prevent "draw holes" from being formed, and in casting aluminium bronze a similar necessity is found. The only way to insure against the evils of shrinkage in this metal, with work requiring "risers" or "feeding heads," *is to have them larger than the body or part of the casting which they are intended to "feed."* The "*feeder*" being the larger body, it will of course remain fluid longer than the casting, and, as in cast iron, that part which solidifies first will draw from the nearest uppermost fluid body, and thus leave holes in the part which remains longest fluid. This part is cut off in the finished casting. A method which I originated and found to work well in assisting to avoid shrinkage in ordinary castings of aluminium bronze was to "gate" a mold so that it could be *filled or poured as quickly as possible, and to have the metal as dull as it will flow and yet secure a fully run casting.* I have made in this way very disproportionate castings without "feeders" on the heavier parts, and upon which "draw" or shrinkage holes would surely have appeared had the metal been poured "hot."

The principle employed in making large castings from this bronze is similar to that used in casting steel, and, as is well known, consists in pouring through a spout controlled by a valve, which allows the metal to flow from the bottom of a ladle instead of the top, or lip, as is practised in pouring cast iron. The exact plan which I used for castings weighing over fifty pounds was to make a "pouring basin" sufficiently large to contain all the metal necessary to fill the mold, the "feeding heads" and "gates," and leave a surplus for a "flow off." No metal was allowed to enter the mold until all was in the "pouring basin." The entrance to the "gate" was stopped by means of an iron plug, and the moment all was ready it would be pulled, and the metal would almost fill the mold, so large would its gates be made. Instead of a "pouring basin," a "secondary pot" or ladle can often be well used. By such plans it will be seen that there was *no danger* of any "scum" or oxide entering the mold, which would seriously mar the appearance and lessen the strength of a casting. Again, the pouring gate is air tight, hence the falling metal cannot, as by the ordinary method, entangle within itself air bubbles, which would be carried into the casting and create "blow holes" in cases where the metal chills quickly. I explained this a year ago at the meeting of the American Society of Mechanical Engineers. This theory has since been beautifully illustrated by W. F. Durfee, M. E., in his paper entitled "Iron and Steel and the Mitis Process," presented to this honorable society, May 11, 1887.

From blow holes, castings of aluminium bronze are free. Should any exist, it is the fault of the molder or his mold. It contains no gas to liberate at the moment of solidifying, as is the case with most steel. The Otis Steel Company, of Cleveland, Ohio, can and do perfectly overcome this difficulty in steel castings. Sand molds for heavy work *must be well "vented"* and of "dry sand." For "blacking the molds," use the same mixture as is found to work well with cast iron. The metals run well in our ordinary molding sands, also iron chills or molds, and "peel" perfectly. The bronze having such a low

"*pouring*" temperature, presents many advantages to the founder in molding and procuring massive castings. This, in connection with its perfect homogeneousness, gives properties very essential in approaching the ideal of perfect gun metal. I have made many perfect castings from these new alloys, and hence my familiarity with their characteristics.

The Rodman method of casting has done its work so well with cast iron, that, considering the features I have mentioned above in connection with the physical properties of the aluminium alloys, good results should be obtained by its application in casting these metals.

The information which is being obtained by your discussions on the fabrication of heavy guns is very valuable and instructive to the metallurgical world, and will ere long, with the wise discretion of our officials, once more assist our government to come to the front in heavy ordnance.

Professor CHAS. F. MABERY.*—*Mr. Chairman and Gentlemen:*—In answer to your invitation to express opinions concerning the paper of Alfred H. Cowles on aluminium bronze for navy guns, it may be of interest to call attention to the peculiar property aluminium bronze has of resisting the action of ordinary corrosive agents. The durability of a gun evidently depends to a certain extent upon the capability of the metal of which it is constructed to withstand the corrosive action of the products of explosion; and of two metals with equal qualifications in other respects, the one that possessed this property in a high degree would have a decided advantage over the other. It is well known that no common alloy can compare in this respect with aluminium bronze. The peculiar nature of this alloy, which approaches that of a chemical compound, serves to protect the copper from oxidation, and the resistance of aluminium to the action of sulphur seems also to diminish the readiness of copper to unite with this element. Carbonic dioxide and nitrogen, the chief products of the explosion of gunpowder, would not affect aluminium bronze, and the same would doubtless hold true concerning the gases formed in smaller quantities—carbonic oxide, hydrogen, hydric sulphide, sulphur, and oxygen. Neither would the principal solid products of an explosion—potassic sulphate and potassic carbonate—corrode the metal; and the sulphur compounds—potassic sulphide, potassic hyposulphite, potassic sulphocyanate, etc.—would probably have little effect upon it.

Another distinctive characteristic of aluminium bronze is its freedom from liquation. The aluminium does not melt before the copper, and, except a very slight loss from oxidation, no change in the proportions of the alloy is observed after a series of meltings. In this respect the metal is superior to the tin bronzes, in which, as is well known, the tin is liable to melt away from the copper, thereby changing very materially the nature of the bronze. Aluminium bronze would doubtless be free from this defect, since no change in the proportions of its constituents would result by liquation at any temperatures below the melting point of the alloy.

*Case School of Applied Science, Cleveland, Ohio.

It has been suggested that the superior strength of aluminium bronze manufactured in the electrical furnace over products obtained by melting together copper and aluminium, may be due to a more complete incorporation of the constituent metals during the process of reduction. Whether this is true, or whether, as seems more probable, the greater strength depends upon the small percentage of silicon usually present, has not been fully determined by experiment.

Dr. R. J. GATLING.*—*Mr. Chairman and Gentlemen:*—I have read with deep interest the advance copy of the paper, "Aluminum Bronze for Heavy Guns," by Mr. Alfred H. Cowles. I will not attempt any criticisms of the author's views upon this important subject. I quite agree with him in all he has said in his valuable paper. I believe the coming large cannon will be a gun cast of either steel or aluminium bronze. I do not believe in "built-up" guns, for reasons given hereafter; such guns are more expensive to make, and are, in my judgment, not so safe, and are less durable than guns cast of steel or bronze. Built-up guns may be able to withstand the internal pressure that they may be subjected to, but the great objection to such guns is not only their cost, but their inability to bear the continuous shocks and strains produced by the force of the gases, and the vibrations and wave motions engendered at each discharge.

There are two kinds of vibration or wave motions produced at each discharge: one is produced by the force of the powder gases, and the other is caused by the recoil—the latter is quite as deleterious as the powder strains. In a built-up gun there are many joints in its exterior surface, and the vibrations and wave motions produced at each discharge are checked at the joints, and ultimately produce crystallization and weakness of the metal at such joints. These are facts which explain the short life of built-up guns. The great durability of the Rodman guns is not solely due to the way they are cast, but to their uniform and smooth exterior surface. Guns should not only be made of strong, tough, and springy metal, but should be, on their outer surface, free from joints or sharp angles. I will say in this connection, the lighter the gun the sharper will be the recoil and the greater will be the vibration or wave motions produced at each discharge; it is therefore better to have the guns of good weight (especially guns for fort use), so that the weight of metal may assist in taking up the recoil—one pound in the gun will do more to check and take up the recoil than two pounds in the carriage. I believe, as steel can now be produced cheaply and in large quantities, that heavy guns can be cast of that metal, or of aluminium bronze, on the Rodman plan that will be the largest, cheapest and best guns ever made. Such guns can be made, if necessary, of one hundred tons weight, to use a charge of, say, six hundred or seven hundred pounds of powder, and discharge a ball of a ton in weight, and have a range of ten or twelve miles. It is needless to say that such guns are greatly needed for the national defenses.

* The inventor of the Gatling gun, Hartford, Conn.

Mr. ROMAINE C. COLE.*—*Mr. Chairman and Gentlemen:*—I regret exceedingly my inability to be present so as to add personally my testimony in this, which appears to me one of the most important discussions that has perhaps ever been brought to the attention of the Institute. It is a subject that every patriotic citizen and property-holder of our country is interested in fully as much as our army and navy engineers and other scientific men.

From the American clipper-built ship the world derived some new ideas in marine architecture; and it does not appear, from recent aquatic sports in the vicinity of New York Bay, that our fund of knowledge in this direction has been exhausted yet. From the American monitor sprang those mighty ironclads that to-day form the bulwark and safeguard of European nations against foreign invasion. To an American, Europe owes her repeating cannon, and, if I mistake not, her repeating rifles as well.

Considering these and the Zalinski dynamite gun, which many think is destined to revolutionize modern warfare, can it be justly said that "to Europe and Europe only must we look for our models and our methods"?

That this tendency toward veneration of everything European exists is well known, and in nothing is it more strongly evidenced than in this question of made-up steel guns.

While the subject of cheap aluminum has excited the scientific interest of the Old World for about 30 years, it has remained for two American brothers to solve the problem; and should our Government avail itself of the advantage here offered them, it is not unlikely that with but a small fractional part of the experience with aluminum bronze applied to ordnance that we now possess with steel, guns could be made of the former metal that would so far surpass those of the made-up principle in points of power, endurance, and cheapness, as soon to place our armament in advance of those of Europe.

Is the conclusion that steel is the only metal of which to build guns wholly warranted? Does it follow, because a mass of steel, forged, oil-tempered, and annealed is such an extremely strong metal, that when such masses are assembled they make the strongest and most serviceable gun?

Touching the unreliability of steel guns, I quote the following, published under my name in the *Mining and Engineering Journal*, of January 22, 1887: "Tests with a new 9.2-inch steel rifle by the British Admiralty go to show that the life of this gun does not exceed 200 rounds, while the bursting of the wrought-iron gun on board H. M. S. Thunderer, causing terrible loss of life, and of the 6-inch steel gun on H. M. S. Active, are well known.

The initial velocity and other merits of the gun are not denied.

Under this head also we quote the following article taken from the Boston *Manufacturing Gazette*, which illustrates the situation admirably: 'The steel gun craze begins to subside not only here, but abroad. The bursting of the 43-ton gun on the English gunboat Collingwood, with only 221¼ pounds of cocoa powder, instead of a full charge of 295 pounds, emphasizes the brittleness of steel, and has induced the British Government to order the cruiser Colossus, fitted with two such guns, to cease firing them. Then Mr. Krupp, who started

* Of the Cowles Aluminum Co., Chicago, Ill.

his 16-inch 120-ton steel guns so enthusiastically in the turrets at Spezzia, was chagrined to find, after 40 rounds, grave defects in the bore, and at the end of the 66 rounds the guns were in too dangerous a condition to continue at work. Both were condemned at a loss of $360,000. This has been the experience of steel for six years, beginning with the 100-ton Armstrong gun that burst in 1880 on the Duilio, and will no doubt continue, on account of the variations in temper that are sure to follow the twenty or more parts from which a steel gun is made. Even the last lot of 100-ton guns that Armstrong made for the Italian Government have, with their first usage, shrunk where they have been welded so as to let the water used to swab them trickle through, and so have all been condemned.'

Mr. William Metcalf, of Pittsburgh, one of our most distinguished American metallurgists, speaking of made-up steel guns, says:* 'The objections to this method of forging are its great cost, its uncertain results, and its limitations. By this method it is necessary to make a gun of many pieces, a built-up gun, because the whole gun cannot be hammered successfully in one piece. The cost of heating and hammering the various parts is large; and after this is done, each piece must be machined accurately and at still greater cost; and when the whole is assembled it is an unmechanical agglomeration of uncertain strength.'

It is a fact that the official evidence regarding the endurance of steel guns is extremely meagre. As Mr. Hunt, of the South Boston Iron Works, truly says: 'To be sure, there have been published by Armstrong, Krupp, and the Woolwich authorities, certain performances of their guns. With carefully selected powder, and where great pains were taken, an additional velocity of a few hundred feet per second was attained without destroying the gun. But such tests are not endurance tests, though they serve the purpose of advertisements.'"

The causes to which Mr. Cowles attributes the failures of steel guns, common sense would seem to affirm.

The effect upon a number of plates laid together when struck by a shot, as stated by him, may be further illustrated as follows: Lay a number of billiard balls in a level trough, all in contact. What will be the position of the balls after being struck by another ball which is rolled with considerable force against them? As is well known, the first and last ball come to rest at points farthest from the others, while the original positions of the remaining balls have all more or less changed. The tube of a made-up gun is the first ball—the hoops, the last.

Does it require any very subtle knowledge of the art of gun fabrication to see readily that where these external layers are already under great tension, approximating closely to their elastic limit, the stress which comes upon them is liable to exceed that limit, and, because of a small reserve in elongation, a complete rupture may take place? This tendency toward rupture of the external layer of the gun is greater than in the last plate of Holley's illustration, because in the case of the former a small distension of the metal at the bore means a much greater distension at the circumference, the extent being

*Army and Navy Journal.

proportional to the distance from the long axis of the gun. In spite of all precautions, certain portions of the external layer will give more compressional stress than others, because of variations in the temper, in the amount of machining to each part, and in the shrinkage; hence, those parts that are under the greatest tension have to bear "the full brunt of the blow."

When we consider these facts, does it not seem clear that toughness is what is needed in the external layers in order to ensure safety from explosion?

The amplitude of the vibrations of the reflected waves of distension being greatest, as Mr. Cowles points out, at the bore of the gun, may be sufficient to stretch the metal beyond its elastic limit, since the tube has the lowest elastic limit of any part of the gun. This may explain why it is we hear so much about the distortion and enlargement of the bore which so frequently prematurely disables the gun.

A good portion of the great elongation now specified for the tube might well be sacrificed for a higher elastic limit. Indeed, while the tube as made serves as an excellent medium for the transmission of the waves of distension to the external layers, it fails, because of its weakness, to add its just proportion of stability to the gun. In a gun cast in one solid piece, all the sources of weakness described are avoided. No one can doubt that herein lies the secret of the remarkable success of cast-iron guns, not one of which, cast on the Rodman plan, has burst since the improvement of slow-burning powder in 1870. There are on record any number of tests made before 1870 of 10-inch and 15-inch smooth-bore cast-iron guns where the pressure has been registered as high as 100,000 and 200,000 pounds to the square inch, and where the endurance ranges from 300 to 2450 rounds.

Assuming that the gun of the future will be made from a solid casting, what advantages has aluminum bronze over steel and cast iron for this purpose? It is a recognized fact that castings of steel are more lacking in homogeneity or soundness than almost any other metal; besides, it is an utter impossibility to attain in a steel casting, even after annealing, the high degree of tensile strength, elasticity, and elongation combined which characterize certain grades of aluminum bronze. I speak from experience, being familiar with the metallurgy of aluminum and its alloys, and having seen large and perfect castings made of the bronze in question.

Among the advantages a cast gun of aluminum bronze would have over a steel gun would be that of its comparative freedom from the effect of crystallization from repeated shocks, which property in steel very likely accounts for many of the disastrous failures of the made-up guns, though it would undoubtedly prevail to a less extent in a solid steel gun were such a gun practicable.

In estimating ultimate cost, it must be remembered that the metal in a worn-out gun, a worn-out carriage, etc., of aluminum bronze is just as valuable as the ingot metal from which it was made, and can be melted up and recast repeatedly without injury to the quality of the metal. With a worn-out steel gun the case is quite different.

In comparing aluminum bronze with cast iron, it is sufficient to draw attention to the much higher degree of power and safety that is probably attainable

in a gun of the former metal; and that, too, with considerably less weight, which factor is of importance, on board ship especially.

Gun carriages for heavy ordnance are made of steel in sections. If made of aluminum bronze the carriage could be largely cast in one solid piece, and be stronger and cheaper.

Armor plates of steel are very expensive because of the amount of work expended on them. A *cast* plate of the bronze should resist penetration as well as steel, while repeated shocks will not crystallize and finally crack it.

One of the disadvantages of the ordinary gun-bronze for ordnance has been that repeated firings had a tendency to recrystallize and dissociate the metals, causing, possibly, a complete liquation between the tin and copper. It is believed that this phenomenon would not take place in aluminum bronze, as that metal is considered a *chemical* alloy, and not a *mechanical* mixture.

It may be argued that, as the fusing point of aluminum bronze is considerably below the fusing point of steel or of iron, the highly heated powder gases at the moment of explosion would, if the firing be kept up, injure the interior walls of the gun. The test with the heated test-bar performed by Mr. Cowles and Lieutenant Hall, where the temperature of the metal was elevated to 400 degrees without apparently decreasing the strength, was certainly an encouraging one. It has been observed in rolling plates of aluminum bronze in a steel mill while hot that the metal is far more refractory at a dark red heat than similar plates of mild steel, though at a very bright red the case is reversed. From this it would appear that aluminum bronze is no more affected within the range of temperature to which the metal about the bore of a gun is subjected from the beginning to the end of a bombardment, than is mild steel, if as much. However, this is a question that should be satisfactorily decided by the Government.

In case it is found that in very heavy guns a steel tube is necessary, the bronze envelope cast in one solid piece being shrunk on after the manner adopted by the South Boston Iron Works for cast-iron guns, we should simply be substituting for the iron a metal three times stronger combined with great toughness, whose coefficient of expansion and heat conductivity would be so near that of the steel tube as to reduce any strain arising from heating to a minimum.

Mr. WM. H. BROWN.*—*Mr. Chairman and Gentlemen:*—The paper of Mr. Cowles upon "Aluminum Bronze for Heavy Guns" calls up the fact that in alloys it is impossible to obtain a constant composition. In casting bronze metal, the temperature of the casting and the method of cooling have a great influence on the qualities of the alloy. Slow cooling diminishes the strength very much, and a reductive powerful enough to eliminate all the gases is necessary. The use of the oxide of aluminum may aid in the bronze production, as much as phosphorus has done, and may be equally valuable, as an alloy, in steel, as is claimed for it; but the fact remains that a *uniform fixed composition* cannot be obtained, for the metals will separate into alloys having different proportions, which weaken their value and reliability. I caused,

* Manufacturer of Seamless Steel Tubes, Jersey City, N. J.

years ago, an alloy to be made of aluminum and copper and had it tested at the Frankford Arsenal by the late Col. Lyford, then in charge there. It was made into cartridge cases, and is a matter of record. It is enough here to say that in some respects it was an improvement; but in resistance to shock of firing and endurance it was no material improvement. If a fine wrought metal of copper and aluminum, carefully prepared by experienced producers, did not, by the addition of the aluminum, show any improvement against the shock of explosion, how can a casting with a cavity show such improvement as Mr. Cowles claims for it? The built-up gun of Capt. Blakeley's conception, mentioned by Mr. Cowles, and the wire gun, will be reached, at no distant day, by placing one steel tube over another, thus overcoming the want of longitudinal strength in the wire gun, and giving any grade of temper that the tensions of the metal demand to meet the strain of explosion, besides making secure the hoops and tube bore of the gun. The difference in cost of construction must be largely in favor of steel, and the difficulties attending the bronze construction largely surpass steel. I am a convert from alloys to pure metal in all construction, although a worker of alloys all my life.

P. A. Engineer G. W. BAIRD.—*Mr. Chairman and Gentlemen:*—I desire to give you a brief sketch now, and I trust more at a future day, of an aluminium bronze reel I designed for the Fish Commission. The reel was for a sounding machine to carry about 5000 fathoms of No. 28 piano wire, and it was essential to get as little weight into it as possible. Our built-up steel reels had not been altogether satisfactory, and I believed we could do better in this new bronze, which was represented as particularly strong. To insure the best possible casting, I informed the Cowles Electric Smelting Company of the purpose for which the reel was to be used, that the pressure upon it would be crushing and not tensile, and gave them the order to make the casting from our pattern. I was not able to obtain from them the actual crushing strength of the metal, though I asked. The percentage of aluminium was left entirely to the Cowles Company. We obtained a fair casting. It was a difficult casting to make, and I feel sure that the metal flows quite as well as any of the bronzes. In finishing the casting we discovered that one side was much softer than the other, from which I infer that the metal was not thoroughly mixed, and it is my belief that a test specimen cut from each side of our reel would give quite different physical results.

Our reel has been tried and has answered its purpose admirably. What crushing stress has been on it I cannot even estimate, as about 3500 fathoms of wire were wound on at a low tension, and after sounding in 2000 fathoms this latter quantity was rewound at a tension varying from 80 pounds to zero. While I would be glad to urge the use of this alloy for reels for sounding machines, I should advise great care in mixing and pouring the metal for heavy guns. It is easy to see what an enormous advantage it has in some respects over iron or steel for guns. It is apparent that we could re-arm the Navy at much less cost and in vastly less time by the substitution of aluminium bronze for the built-up steel guns our people are now struggling with. I feel

some embarrassment in offering advice in the matter of material for guns, as it is so foreign to my calling; but it is a matter which affects the service as a whole, and I trust my experience with the reel may be of use to those who are building the great guns for the coming navy. While my words may be construed as testimony against the bronze, I do not wish to be understood as saying or believing this trouble is insurmountable; on the contrary, I believe that with experience these two metals (copper and aluminium), which have such a difference of density, will be alloyed with great success.

Mr. J. R. HASKELL.*—*Mr. Chairman and Gentlemen:*—Having been honored with an invitation to be present and to take part in the discussion on the paper on "Aluminum Bronze for Heavy Guns," by Alfred H. Cowles, or to send my "opinions and criticisms in writing" in case it should be impossible to be present, I have the honor to inclose this communication in compliance with that request.

There are two questions in regard to the construction of guns: First, the kind of metal of which they should be made; and second, the manner of construction. The first of these propositions only is to be considered in this paper, although the latter is perhaps of more importance than the former.

I have examined closely into the subject of the best metal for the construction of heavy guns, and I place them in the order of excellence as follows: 1st, aluminium bronze; 2d, cast iron; 3d, steel.

In stating this order of merit for the metals a good deal will depend upon the manner of constructing the guns and projectiles, but I am convinced that if the guns are constructed upon the proper plan, the order of merit for the different metals will stand as I have stated them. I give this opinion based on a practical experience of a third of a century spent in constructing and experimenting with breech-loading rifled ordnance and projectiles. I have my own idea of the best way of constructing guns, but that subject is not under consideration at this time, although it has an important bearing upon the question of what metal is best to use.

In the paper of Mr. Cowles, now before me, he has stated the advantages of aluminium bronze as a metal for constructing heavy guns, in which statement I fully concur. He has given a table showing the physical qualities of the metal, which shows it to be fully equal to steel, if not superior; and at the same time he demonstrates that it possesses other qualities which steel does not, which makes it superior to steel as a metal for constructing guns.

In making guns of ordinary gun bronze, they must be made of new metal, and good bronze cannot be made of old guns, as the tin burns out in remelting, and the exact proportions cannot be arrived at. A certain proportion of zinc has to be used as a flux to aid in uniting the copper and tin. I am aware that the Ordnance Manual of the Army gives 9 parts of copper and 1 part of tin as the composition used, but all the bronze founders I have employed say that a little zinc must be used as a flux. Now, in making aluminium bronze no flux is needed, as aluminium thoroughly unites with the copper, and with all other

* Inventor of the multicharge gun.

metals. It increases their fluidity, and much finer castings can be made with any metal when alloyed with aluminium. Wrought iron when alloyed with aluminium can be melted and cast in molds, and as an evidence of its perfection for purposes of casting, curry combs having very fine teeth can be perfectly cast from it while still possessing the qualities of wrought iron. The aluminium, when once alloyed with copper, does not burn out in remelting as tin does, and therefore old guns can be remelted and used over again in constructing new guns, the metal being fully equal to new metal.

Aluminium bronze is a much better conductor of heat than steel or cast iron. This is a great advantage, for the reason that the guns, after they are cast, will cool more evenly than either steel or iron, and therefore there will be less tensions created by unequal contraction in the cooling of the guns, neither will there be so much danger from unequal expansion when guns are fired with great rapidity. This is an advantage to which Mr. Cowles does not allude. These tensions are such, in some instances, that large guns have burst in the lathe after work had been commenced in turning them off.

In making large masses of steel for guns it is impossible to have it entirely homogeneous. There will be places in it where it is harder than others, and this inequality is detrimental to the gun. In aluminium bronze there is a perfect union between the two metals. It is not a mere mixture, but there is a chemical union, and the bronze is perfectly homogeneous. In this respect it is very much superior to steel for gun making.

I am so thoroughly satisfied of the superiority of aluminium bronze over any other metal for the construction of guns, that I have determined to make an eight-inch multicharge gun out of this metal, as made by the Cowles Electric Smelting and Aluminium Company.

There are two points in Mr. Cowles' paper which I do not approve, and although he advocates them, my opinion is that they will prove an injury to his metal if they are adopted. I propose to review them and give my reasons for disagreement. One of them he recommends is the Rodman system of casting guns, and the other is the Dean plan for hardening the metal around the bore. It will be necessary to explain somewhat at length the history of the adoption of one of these systems into the service, for the reason that this adoption has given an importance to the system which its real merits do not deserve. I refer to the so-called "Rodman system" of casting guns and cooling from the centre. The Rodman system of casting guns was a failure from its commencement—never a success. It claimed to cool the castings entirely from the inside, which was never done. The castings cooled from both the outside and inside. It is true that a fire was kindled in the pit outside of the flask, on the pretense of keeping the outside metal hot and having the cooling all carried on from the inside, and a stream of cold water was continually flowing through a pipe in the centre of the casting, carrying off the heat. It was found, I have been informed, that the fire in the pit caused the expansion of the flask, and thus loosened the sand so that many castings were lost, and that it was then abandoned. One fact, however, would show the entire fallacy of this pretense of heat outside the flask. The heat would have to be sufficient to heat the flask red hot to prevent

outside cooling. In the cooling of guns, the parts that remain fluid or red hot the longest give way to the parts that first become cold or set, and the shrinkage draws apart the red-hot metal and produces cracks or porous places in the metal where the greatest degree of heat remains the longest.

The diagrams below show the effects produced in the cooling of large gun castings. Figure 1 is a cross section of a gun cast solid, and shows the effect

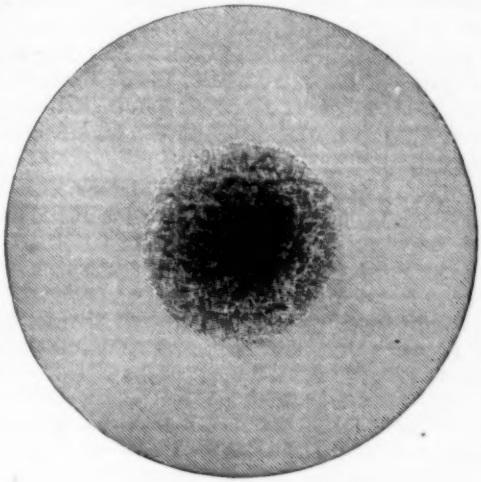


FIG. 1.

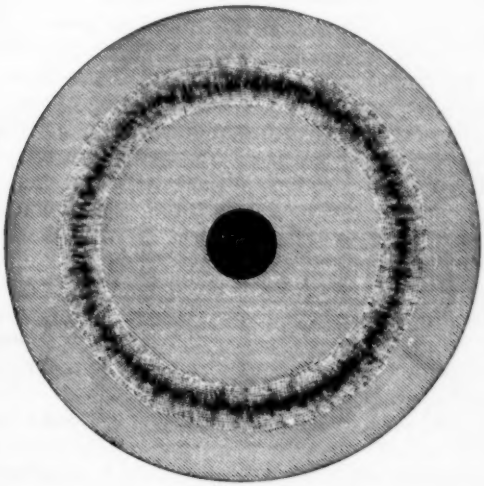


FIG. 2.

on the metal of cooling from the outside, in which the inside metal remains fluid the longest, and the drawing apart and checking take place in the centre. In this case the injured part of the metal is bored out in finishing the gun, leaving the solid metal surrounding the bore. This is the manner in which the Dahlgren guns were cast. Figure 2 represents a cross section of a gun cooled from the centre on the Rodman plan. In reality the gun is cooled from the centre and outside also, and the cut shows the effect on the metal when the parts which are hot the longest are those surrounding the bore. Guns cast in this manner are not as strong or durable as those cast solid and bored out.

This Rodman system of casting guns was forced into the Navy against the protests of Captain Dahlgren, one of the ablest ordnance officers in the Navy, and whose guns cast solid had never been known to fail. Captain Rodman had some 10-inch guns cast solid, which he caused to be made in such manner as to produce failure, in order to aid in securing the adoption of his system. The guns, however, which were made under the direction of Captain Dahlgren at the same time all proved good, none of them having failed.

The patent of Captain Rodman was for casting a gun hollow and cooling the casting from the inside. The Rodman gun was adopted for the United States service upon the result of a trial during which fifteen guns were cast and proved, *of which eleven burst.* (See Rodman's Experiments, page 133.)

Colonel Bomford had made a 12-inch gun in 1845. It was fired 100 rounds with the severe powder in use at that time, and was not injured in the least. It was of larger calibre than had ever before been attempted of cast iron for a smoothbore cannon, and no rifle of large calibre was then contemplated by Captain Rodman or any one else. The account of the test of Colonel Bomford's gun can be found on pages 111 to 123 of "Wade's reports of experiments on the strength and other properties of metal for cannon: by authority of the Secretary of War, 1856."

None of the guns cast hollow and cooled from the interior previous to the adoption of the Rodman plan (1859) were of larger calibre than 10 inches.

As smoothbore shell guns, no cannon of large calibre had ever exhibited better endurance than the guns *cast solid* and cooled entirely from the exterior, designed and made under the direction of Captain Dahlgren, especially after they had their injurious tensions relaxed by age—that is, by exposure for years to the mollifying influence of the elements. The changes of temperature from night to day, from winter to summer, had annealed them. After this they could be fired with heavy charges of the most severe powder, and as rapidly as the most exacting conditions of battle required.

Admiral Porter said, in a paper laid before the Joint Committee on Ordnance, 40th Congress: "I have never known an accident happen to the 9, 10, or 11-inch guns, three of the best guns we have ever had in the Navy, and in battle men stand behind these guns in perfect security, knowing that the chance of their bursting is very small." These were Dahlgren guns cast solid and cooled from the exterior.

On this subject, Captain James Alden, U. S. N., testified before the Joint Committee on the Conduct of the War, January 23, 1865, as follows:

By the Chairman :—*Q.* What number and calibre of guns had you on board the Brooklyn in your expedition against Fort Fisher? *A.* We had twenty 9-inch guns, two 100-pounder Parrotts, and two 60-pounder Parrotts—all four of the Parrotts rifled.

Q. How many times were those guns fired in the two attacks upon the fort? *A.* I threw into the fort 3400 9-inch shells—over 120 tons.

Q. How did the guns bear that shelling? *A.* As soon as I heard of the 100-pounders bursting, I put mine on the opposite side of the ship from that from which I was firing, and put in their places the 9-inch guns, so I had twelve 9-inch guns in battery all the time.

Q. Then you did not use those 100-pounder Parrotts? *A.* Not after I heard of the accidents with them on the other ships. I never fired them again.

Q. Were those 9-inch guns made on the Rodman principle? *A.* They were Dahlgren guns.

Q. Were they cast hollow, or otherwise? *A.* They were the Dahlgren 9-inch guns—the best guns ever made.

Q. What effect had the firing upon them? *A.* I never discovered that any of them were injured.

Q. Did none of them fail? *A.* Not in the slightest degree. The men stand around and fight with them with as much confidence as they drink their grog.

With regard to the improvement of the model of the Rodman gun, Admiral Dahlgren resented it as a plagiarism, and in a letter addressed to the Secretary of the Navy protesting against the adoption of the hollow mode of casting for navy guns, printed in the report of the Joint Committee on Ordnance, Senate report committee, No. 266, Fortieth Congress, third session, he said : "I think what Mr. Parrott here states admits of neither question nor qualification. Please to note that the solid-cast 11-inch gun, cast not with any special care, but with no more than is usual in current manufacture of a large number, gave 'more uniformly satisfactory results than the hollow-cast Columbiads of old model, to which the experiments of Major Rodman were for a long time confined.'

"Now note what Mr. Parrott says a little further on : 'But a further experiment was made after the model of the 10-inch Columbiad had been changed, by rounding off the angular breech and giving increased thickness at the bottom of the bore. In this instance both solid and hollow-cast guns endured well, reaching 4250 rounds each without bursting.'

"The plain and direct conclusions from these statements are : 1. That when Major Rodman's mode of hollow casting was applied to the army Columbiad of the old model, my solid-cast 11-inch gave more satisfactory results. 2. And that when the model was changed there was obtained a very striking advantage to Major Rodman's hollow casting. It went 4250 rounds. This would have been a stubborn fact to overcome by itself ; but it does not stand by itself, for a gun of exactly *the same improved model was cast from the same furnace, the same iron, and cast solid as the* 11-*inch guns are cast.* That, too, endured just the same amount of firing as the hollow cast, namely, 4250 rounds.

Well, from all this follows : 1. That hollow casting would not save a bad model. 2. That when the bad model was changed to a better, the solid-cast gun endured just as much as the hollow."

The second point in Mr. Cowles' paper to which I object is his proposition to make use of the "Dean process" for condensing and hardening the metal immediately surrounding the bore of the gun. I am opposed to this as entirely unnecessary and an alleged improvement in the wrong direction. Mr. Cowles, near the commencement of his paper, in giving the qualities which a good gun metal should possess, says, "And its walls should be hard enough to withstand the abrasive action of the projectile." No shot should be used in a rifled gun which has an "abrasive action" on the inside of the gun, and the improvement needed in this direction is not a condensation of the metal surrounding the bore to resist this abrasion by the shot, but an improvement in the projectile itself, and in the rifling of the gun to permit the use of a projectile that will not cause abrasion, but which will be delivered from the gun without injuring it, even as much as a round shot delivered from a smoothbore cannon. The use of such a projectile with a minimum amount of friction will render superfluous all such application of additional strains on the gun to harden its interior.

Mr. Cowles no doubt thought that such a process of interior hardening was necessary because of the effect on the guns of the projectiles now in use in Europe and in this country, and the system of rifling adopted. These are radically wrong, and in order to make this appear more conclusively, and to show how entirely unnecessary is the use of the "Dean process," it will be appropriate to review these systems of rifling and projectiles as now used, and to show wherein they are defective.

The rifling in use in Europe, and imitated in this country, and the projectiles with their manner of taking the grooves, are not made on scientific principles, and are in fact a violation of well known mechanical principles. The rifling starts at the breech with a very slow twist, and then commences to increase in its twist or pitch and keeps on increasing until it gets within a foot of the muzzle, when it becomes uniform from that point to the muzzle; in other words, when the projectile is going comparatively slow the rifling is almost straight with a very slow twist, but the higher the velocity becomes the quicker the twist. To illustrate: if a curve commences on a railroad track at first with very slight curve, run the engine very slow; as the curve becomes sharper run the engine faster, and at the sharpest part of the curve run the engine the fastest! This is the system on which the guns now being constructed for our Government are being rifled. There is neither science nor common sense in such a system.

The projectiles in use in these rifled guns are even worse than the rifling; they are of two kinds, either expanding or force—*i. e.* slugging projectiles, where the bore of the gun acts as a die in which the shot is forced through, imprinting on the shot the grooves and lands of the rifling.

A distinguished officer of the English Navy, and author on the science of ballistics, Captain Dawson, R. N., in a paper read before the Royal United Service Institute, said, referring to the "Woolwich Infant" in 1873 (which had been disabled), ten years after the adoption of that unburstable and costly system: "Thus in the course of thirteen horizontal discharges, spread over five weeks, maximum pressures are evolved from two identical 120-pound Waltham Abbey Pebble (powder) charges of 20 and 60 tons respectively. The

problem of the Surveyor-General of Ordnance might well assume a different form, for it is not a question here of different amounts or different kinds of powder, of different elevations, or of different chamber temperatures. Every condition is identical. The gun was carefully nursed on both days. It was the third horizontal discharge on each day that we are comparing, and we may assume that the intervals between the discharges were equally large, yet 3½ times greater pressure is registered on one occasion than the other. Why is this? Again I ask, has any powder manufacturer found that carefully made gunpowder varies in its explosive force to the extent of 3½ times the pressure? Do shells explode with 3½ times their wonted violence without cause? Do torpedoes manifest eccentricities to this extent? Do miners find that identical charges of similar powder, fired under like conditions, explode with 3½ times their usual force? Vary the question as you will, nowhere but in a Woolwich rifled gun containing a non-centering shot balanced in unstable equilibrium upon two points, and restricted to a short rifle bearing of one inch in each groove—in these, and these only, do similar charges, fired under like conditions, produce such anomalous results.

There are, of course, waves in a gun, just as there are waves in the sea; but when the waves of the sea singled out and engulfed a particular ship in the midst of a squadron, the common sense of seamen told them that the fault must have been in the ship and not in the waves. And when gunpowder plays such pranks in a gun, every intelligent gunner knows that it is not the gas waves but the *shot* which must be at fault.

Again we are told that it was 'intense wave pressure' and 'local action' which disabled the gun. Now this 66-ton pressure was registered more than 3½ feet from the spot where the whole of the injuries are concentrated. And if the shot had centered itself in the bore, even the 53 tons pressure on its base could not have reached within several inches of the damages, so that it is perfectly clear that it was not the direct action of the maximum powder pressure which disabled the gun, but the mechanical movements of the shot acted upon by these great pressures—the two forces—viz. the wriggles of the shot and the combustion of the charge, acting and reacting upon each other."

The projectiles now in use in this country for rifled guns are the same "gun destroyers" so strongly condemned by this able writer on the science of ballistics, and if the United States would save millions of dollars and years of time, the voice of experience and science must be heeded. The increasing or gaining twist makes it necessary to use the objectionable projectiles before referred to by Captain Dawson, R. N., as "non-centering shot balanced in unstable equilibrium upon two points, and restricted to a short rifle bearing of one inch in each groove," etc. In using the gaining twist the bearing must be *short* and restricted as stated, and this is a vital objection to that system of rifling. More guns are destroyed by the use of improper projectiles and rifling combined than by the pressure of gunpowder.

Besides, the immense friction and strain developed by these projectiles not only destroys the guns rapidly, but this same friction robs the projectile of just so much of its energy in striking the enemy.

In May, 1864, Captain Fishbourne, R. N., stated to the United Service Institute, London, "That it required 40 tons of pressure to force an Armstrong lead-coated projectile, of 25 pounds weight, slowly through the bore of a breech-loading rifle gun of that calibre." What then would be the amount of pressure required to force a shot weighing 500 pounds through the bore of a gun in the $\frac{1}{100}$ part of a second? How rapidly would this immense friction rob the shot of its power and tend to destroy its own gun instead of the enemy?

All this friction is unnecessary. A projectile properly made, mechanically fitted, and centered in the bore of the gun, can be drawn through the bore by one man with a small cord. With such a projectile the gun will be preserved, and the projectile will keep all the power given to it by the pressure of the powder gases until it leaves the muzzle.

The gun should be rifled with a *uniform* twist, thus giving the entire twist to the projectile while it is going at its lowest velocity. The shot should be one *that does not alter its shape in the gun*, should be mechanically fitted and centered in the bore of the gun, which will prevent all wedging, wabbling, and balloting in the gun, insuring accuracy of flight through the air, meeting with less resistance from the air than the wabbling projectiles, even if these latter kind do finally centre themselves through their rotary motion in the air. The rifling should be so cut as not to weaken the gun, and to admit of the use of anti-friction projectiles, in order to prevent the destruction of the gun by immense friction, and waves of enlargement running through the gun with the velocity of the projectile, thus robbing the shot of a large portion of its energy by this unnecessary friction.

Mr. Alfred H. Cowles.—*Mr. Chairman and Gentlemen:*—The papers read this evening seem to show that there has been a misunderstanding as to the position held by me on the "built-up" gun. No matter how small an improvement can be made, expense in gun fabrication should not be spared in making that improvement. This is true to a very large degree; and, as stated, the built-up gun shows from my point of view about thirty-three per centum increase in efficiency over the old cast-iron guns. This improvement gives ample justification for the additional expense incurred in building up guns of steel.

One of the gentlemen stated that the coefficient of elasticity is a feature that is one of the banes of existence to the artillery engineer who designs a "built-up" gun, and that it will perhaps be a surprise to the lecturer to learn that this same coefficient will be harder to handle in casting than shrinking. It is strange the cast guns of weak material have done so well; but this feature is only handled once there, where it may enter into the calculations twenty times in building up a gun. Ensign Glennon remarks that the deviation in tension mentioned by me is $\frac{1}{2000}$ to the inch. It is not surprising that he should have been misled, as there was an error in the copying of my manuscript, where $\frac{2}{1000}$ was made to read $\frac{1}{2000}$; however, an error of $\frac{2}{1000}$ of an inch in the proper diameter of a 17-inch ring causes a wrought-iron built-up gun to lose forty per centum of its calculated strength, which is equivalent to the metal of the walls being in repose. With steel a little more leeway would exist, as its elastic extension is a little greater than wrought iron. Mr. Glennon asks further:

"Why not start with a mild steel of 70,000 pounds tensile strength, 30,000 pounds elastic strength, and thirty per centum elongation, and subject it to the mandreling process? What is there in this process that would apply to aluminum bronze and not to steel?" There is nothing. If you can obtain the cast steel in the form of a large and perfect gun casting, mandrel it by all means. It is the most perfect way of obtaining a nice system of varying elasticity from the centre outwards. Mr. Glennon says it is already practiced on the mild forged steel tubes of large guns. He, however, has selected the form of steel that is most difficult to cast. Its melting temperature is more than twice that of the bronze and higher than hard steels. It absorbs gases when molten and gives them off on solidifying. Krupp may properly be called the father of the method of casting large masses of steel. His first guns, which were failures, were cast-steel guns. Until the time of his death he kept abreast with all improvements in the metallurgy of steel, but was never able to return to his early and ideal method of obtaining solid guns of steel. Mr. Glennon is further inclined to class aluminum bronze with ordinary gun bronze, and attributes to it a tendency in its elements to separate during solidification, or from the effects of heat and vibration. The able papers of Professor Thurston and Professor Mabery will undoubtedly give him more information on this and other points. As to his criticism that the metal in the tube of a gun must withstand a temperature between 3000 and 4000 degrees Fahrenheit—this is true, but it is for only the one hundredth part of a second. Faraday demonstrated that in the flame of a candle a fine platinum wire could be melted, showing an equally high temperature; yet one may thrust tissue paper within that flame and it will not ignite unless it has many hundredths of a second for the minute films on its surface to become heated. Time is an important element in determining the amount of heat one body will conduct away from another. The molecular movement of the metal in the walls of a gun is sufficient to account for the rise in the temperature of the gun, and this tends to distribute the heat throughout the whole thickness of the walls. The effect of the friction of a rifled ball can only be determined by use and experiment. A steel tube would obviate any difficulty that could arise within the bore of a gun, and would supply a remedy if needed.

Thanking you for the interest manifested, I close, resigning the cudgel to my brother, Eugene H. Cowles, who, at a later date, will answer more in detail the objections that have been raised to the use of aluminum bronze.

The CHAIRMAN.—In the brief remarks that I have to make this evening, I shall not enter upon any discussion of the qualities of aluminium bronze or of its suitability for purposes of gun construction. But I wish to direct attention to a radical misconception which seems to me to lie at the base of much of the argument which has been lately heard, here and elsewhere, upon the subject of a proper material for guns.

The gentlemen who within the last year have appeared before this and other audiences to propose substitutes for the material now used, have based their recommendations, first of all, upon the assumption that a new material is urgently necessary, that now in use having shown itself hopelessly unreliable.

This assumption they do not attempt to establish by the citation of evidence, but content themselves with such statements as the following from the paper of this evening, "I need not refer to the many failures of steel guns," etc. As the lecturer is dealing with guns of the present day, and not with those of twenty years ago, it is fair to assume that when he says "steel guns" he means such steel guns as are now in use; that is to say, steel *built-up* guns.

I have no doubt the sentence quoted was written in perfectly good faith, and that the lecturer believes that a large number of built-up steel guns have burst. This is a belief very commonly held, even among people whose sources of information ought to be reliable. It seems to rest to a great extent upon a widespread but entirely erroneous idea that the artillery of England is principally of steel, and that the frequent accidents reported from English ships and forts have been in steel guns. The fact is, that the number of steel guns in service in the English Army and Navy is quite insignificant in comparison with the number of wrought-iron guns.

About the beginning of the present year a return was made to Parliament of the number of English guns that had failed in the twelve years preceding. The list includes 31 guns, designated by their numbers and marks. A comparison of the list with a descriptive table of ordnance issued by the War Office, shows that of these 31 guns only two were of steel: the 6-inch gun of the Active and the 12-inch gun of the Collingwood. To these should be added a 9.2-inch gun which failed in trial.

Reports have been frequent of the bursting of Krupp guns, but, so far as I can learn, only one such report is capable of confirmation. This is the case of a 10-inch Krupp gun which burst at Fort Heppens in 1884. It will be understood that I still speak of *built-up* guns, the manufacture of which by Krupp dates from 1872.

To the four examples cited above of all-steel built-up guns which have failed in service or test, must be added a DeBange gun of 42 centimetres calibre, the muzzle of which was blown off in France in 1885.

The large number of built-up steel guns which are authoritatively recorded as having burst reduces itself, then, to five. With regard to these, it is interesting to note that without exception they failed only in the chase, forward of the hooping; that is to say, at the point where it had been attempted to give the necessary strength by a single ingot unassisted by the building-up principle. In every case the fracture of the tube was stopped short at the first hoop. In fact, the DeBange gun mentioned was reported as entirely serviceable after the accident, and other guns have actually been built upon the model presented by this gun after he loss of its nineteen inches of unhooped muzzle.

Such a thing as the failure of the built-up portion of a steel gun is, I believe, absolutely unknown; and all authorities who have discussed the accidents quoted above have been forced to the conclusion that the guns would not have failed if the hooping had been continued to the muzzle, as it is in the latest designs.

With regard to the lecturer's statements that to realize satisfactorily the conditions involved in the principle of initial tensions "is generally conceded to be a mechanical impossibility," and that "practical men consider the nicety of

workmanship required for this as impossible of attainment," it need only be remarked that Sir Joseph Whitworth, Sir William Armstrong, and Herr Krupp have been generally conceded to be practical men, and they have all believed that the construction of such guns was not only possible but very simple.

The lecturer says that cast-iron guns have been known to stand pressures far above the tensile strength of the metal without apparent rupture, but it is doubtful whether or not a steel gun has ever stood such a pressure. As the tensile strength of the steel in question is about 43 tons, the lecturer would probably have been safe in saying that no steel gun has ever stood such a pressure, and he might have added that no steel gun will ever be called upon to stand it. And this would seem to be a point in favor of the steel.

On the motion of Commander Harrington, seconded by Commander Sampson, the thanks of the meeting were unanimously tendered to Mr. Cowles for his interesting paper.

The following paper, in reply to some of the foregoing criticisms, was received November 13, 1887:

Mr. EUGENE H. COWLES.*—A careful review of the criticisms that have been made against the proposition to substitute aluminum bronze for steel in the manufacture of heavy guns, shows that our position on certain points is not quite clearly understood by some of the distinguished gentlemen who have honored the discussion with their opinions.

The most important misconception that has arisen appears to be that we have the idea that the old system of cast or wrought-iron ordnance might better have been perfected and adopted than the present system of "high power, all steel, built-up guns." Nothing could be further from the position we hold, or from that advanced in my brother's paper. If we had not held the opinion that the present system of heavy guns is the best that the world has thus far seen, the able remarks of Lieutenants Knight and Gleaves would certainly have convinced us of that fact.

The many references to cast-iron guns were made only to emphasize the fact, that notwithstanding the comparatively poor material of the old solid cast-iron guns, the gain in work done by the new "built-up" steel guns was not proportionate to the higher physical qualities possessed by steel over the cast iron. In other words, a gun of steel of 90,000 pounds tensile strength and of proportionately high limit of elasticity gives us only about forty-five per cent more efficiency than a gun of cast iron of 30,000 pounds tensile strength and a low limit of elasticity, although the steel has fully two hundred per cent greater tensile strength and a much higher limit of elasticity than the iron; and this, too, regardless of the fact that the most perfect and costly workmanship of the world has for the past generation been vainly employed to apply the principle of "initial tension" to the fabrication of "built-up" guns. That

*Member of the Royal Institution of Great Britain, and of the American Institute of Mining Engineers.

solid guns of iron, steel, or tin bronze, either wrought, cast, or forged, should not have been able to keep pace with the rapid advances made in "built-up" guns is perfectly natural. Indeed, when we consider the numerous, and to a somewhat large extent contradictory, physical qualities that must be possessed in combination by a proper material from which to make a solid gun, it could not have been possible that the solid gun should have succeeded in holding its own, when only iron, steel, or tin bronze were at hand from which to construct it.

With these facts in view, and having clearly in mind the reasons why solid guns in the past have not succeeded, the proposition was made that a solid gun can now be constructed of aluminum bronze, because in this alloy is found a combination of all the good qualities of iron, of steel, and of tin bronze, with none of those elements of failure that have heretofore rendered it impossible to make a successful large gun of a single piece. These qualities, physical and chemical, many of them contradictory in other metals, together with the economic advantages, are as follows: A remarkable combination of maximum tensile strength, hardness, ductility, elastic limit, stretch within the elastic limit, compression strength, tenacity, and malleability when hot; of freedom from liquation, freedom from difficulties in casting, non-corrodibility, minimum weight, minimum cost, of shortness of time required for construction—a matter of great importance to Government economy—and finally, the maximum intrinsic value of the metal when the gun is rendered obsolete or injured.

The above claims many engineers may regard as extravagant, and we would be slow to put them forward, were it not that they are the deductions of nearly two thousand carefully conducted and recorded examinations of the properties of the alloys of aluminum and other metals. Each one of these examinations has embraced from four to ten distinct physical and chemical tests of these alloys, and all the important results obtained by us we have had carefully duplicated and repeated many times by eminent experts both at home and abroad. It is scarcely necessary to add that this work has involved many thousands of dollars, not including the half million dollars invested in plants for the commercial production of these alloys.

It is, therefore, with some experience and much confidence that we believe that, if the old cast guns failed and were not as good as the present "built-up" guns, it was because they were made of cast iron instead of aluminum bronze; and further, that, if the Uchatius mandreled guns only held their own up to 1886, and up to 6-inch size, it was because Uchatius used tin bronze or sterro metal instead of aluminum bronze. While still holding the view that the best gun can be made from a single piece and that it is simply a matter of experience, time, money, brains, and a proper metal from which to fabricate it, there appear to be good reasons to believe that the substitution of aluminum bronze for steel, even in the construction of built-up guns, would be a great advance.

The high elastic limit and tensile strength and ductility of aluminum bronze is a result of the aluminum contained in the bronze, and, in the case of forgings, of work done on the same, and not largely that of temper, as with steel. It

has not those uncertainties of strength and tendencies to brittleness which so good an authority as Mr. Daniel Adamson, of the British Iron and Steel Association, in his presidential address, no longer ago than May, 1887, said were liable to be found in steel. At that time he stated that "the greatest evils that have befallen steel guns have arisen from the material used, being composed of too strong a metal having little ductility and special weakness at low color heat, and at best, a material not calculated to resist concussive shock induced by the explosion of gunpowder."

Farther, it can be remarked, as a supplement to the observations of Ensign J. H. Glennon on the matter of ductility in a gun material, that ductility is a reserve of safety that cannot be ignored, especially in a built-up gun, and the higher ductility of aluminum bronze would render it more valuable than steel in a built-up gun, always allowing that the elastic limit and hardness were as they are, proportionately higher in aluminum bronze than in steel. Right here it may be well to introduce a further quotation from President Adamson's address, where he says: "Taking the elaborate discussion on Mr. Dorsey's paper in America, the artillerists may be said to take the view of adopting a strong steel, while the civil and mechanical engineers desire to use a lower and milder steel with much more ductility. No two opinions can exist that the fundamental principle to be observed in the selection of the material to be used for this purpose in the future must be such that no probability will arise that a gun will burst until so disorganized as to render it incapable of further use."

In regard to the question that has been asked, Why would not the Dean process of mandreling apply to the making of a solid steel gun from a mild steel as well as in the case of aluminum bronze? the reply can be made that perhaps it would, although blow holes are not found in aluminum bronze as in steel castings.

In point of fact aluminum bronze in itself has no affinity for any kind of gas to be met with in the casting process, nor does it occlude gas in the melting, as does iron or steel. At times blow holes will occur in castings of this bronze, but they are invariably caused by the air or steam from a wet mold becoming entangled in the metal in a mechanical manner. Aluminum bronze, when cast in ingots in chill molds that are free from oil or gaseous facing matter, the metal being poured in a quiet, steady stream that does not foam, and through the bottom of a secondary or straining pot, is always solid and perfect—a conclusive evidence that the metal does not occlude gas. Steel cast in this manner with the same care is always more or less spongy. The blow holes, as Dr. Gatling suggests, may be gotten rid of by the use of aluminum in the steel casting process, but only actual working experiment will determine whether or not it can be accomplished. The success that many steel founders are making with the ferro-aluminum alloy produced at Lockport, N. Y., would tend to show that efforts in this direction would result in the soundest castings that have yet been made of steel.

It has now been shown that, as advocates of the aluminum alloys for ordnance purposes, the position of Mr. A. H. Cowles, as well as that of the writer,

is one preferably in favor of solid aluminum bronze guns, solid aluminum steel guns, or, if we have to make a virtue of necessity, we should favor the use of aluminum alloys either of copper or steel in the built-up gun. In other words, we have such strong opinions as to the value of aluminum when added to other metals, that we are aluminum men first, last, and all the time, until actual practice shall have demonstrated our theory on this subject to be erroneous.

As to the advisability of the Government making an investigation of these alloys, it has been objected that there is no urgent need of a new material for guns. To this it is only necessary to say that the time never has been yet that man has refused to accept a better weapon of defense than the one he already possessed without in the end paying dearly to some conqueror for his short-sightedness; and it is not now likely that the world in this unexampled age of progress is going to rest content with steel if there is the smallest chance of obtaining a better material. No, we must move on and on, and the gun, or that particular material for a gun, that is regarded as perfection to-day, to-morrow may be obsolete, and in a generation may be looked upon as a relic of ignorance and inexperience.

Since the the war of the rebellion these changes have been almost yearly; cast-iron guns have given way to wrought ones, to compound cast and wrought cannon, to wrought-iron and steel guns, finally to all steel. Guns of cast steel have given way to those of forged steel, forged steel to "built-up" guns, short guns to long ones, smooth-bore guns to rifles, muzzle loaders to breech loaders, large-bored guns to those of smaller calibres, and so it is likely to be to the end of time. For this very reason attention has been called to the intrinsic value of aluminum bronze. During the past twenty-five years there have probably been fifty or a hundred cannon rendered valueless by the constant changes going on, to one that has actually been destroyed in battle or sunk at sea. With wrought iron or steel the loss that has thus occurred has been ninety per cent of labor spent in fabrication. Had these old obsolete guns been of cast aluminum bronze, fully two-thirds of this loss would not have happened, and the old guns, instead of having been used for fence posts, old scrap, etc., would have been recast into more efficient weapons than before. It is not, however, intended by this remark to convey an idea that economy should govern in selecting a material for guns rather than fitness; for that material and that process is infinitely the cheapest that is the best. The argument is advanced simply to show the happy advantage possessed in this respect by aluminum bronze coincident with its other superiorities.

With regard to its cost, sixty cents a pound would be an approximately fair price for it in a finished cast gun. If it is true, as it has been stated, that the Hotchkiss gun, which sells for something like two or three dollars a pound, can be made for much less than forty cents, it is a most substantial reason why there should be a little competition in the United States in the direction of aluminum bronze. The statement made in the opening paper of the discussion, as to the cost of steel guns, has been criticised as being the selling price to the Governments at home and abroad. This is exactly as it should be

understood. The cost to the Government is the selling price of the manufacturer, no matter how low the cost of production happens to be. In some cases, where the Government manufactures its own guns, it may save the manufacturer's profit. In this country, where the work is partly private and the rest done by the Government, the estimate that was made on the cost of steel guns was certainly not too high. In proof of this take the following figures for the unfinished gun steel forging contracts made this year; they surely do not represent more than the first half of the cost of the finished gun. They are as follows: Bid of the Cambria Iron Company on 1310 tons, $851,513.90 = 32.5 cents per pound. Bid of the Midvale Company, 1310 tons, 1,397,240 pounds = 52.25 cents per pound. Bid of the Bethlehem Iron Company, 1310 tons, 902,230 = 34.43 cents per pound. These prices would average higher than the present market prices for ingot aluminum bronze, and the work of converting ingot bronze into guns should cost much less than finishing and assembling rough gun-steel forgings.

With regard to a supply of aluminum bronze, it may be of interest to the naval and military public to know that this alloy would probably be, in case of suddenly threatened war, the most available national resource from which to construct high-powered guns. For it would be entirely possible to erect at least two plants within ninety days that would have an output each of at least one hundred and eighty tons per week of aluminum alloy in ingots of the proper grade for cannon. Foundries of sufficient capacity to handle this amount of metal, if indeed there be not such already in the country, could be built in the same time. The turning, rifling, and finishing plants of the larger guns would of course take more time in their erection. As to copper, there is always four or five thousand tons in store in the United States from which to form the base of the alloy. Contrast this picture with that presented by the Gun Foundry Board when it estimated that it would take three years to build the necessary plant to fabricate heavy steel built-up guns, and two years after that to get the first 16-inch guns out.

Before ending this somewhat protracted paper it is desired that attention be called to the remarks of Mr. Wm. Metcalf. Although we disagree with him on the advisability of discussions like this on the gun question, we cannot but thoroughly coincide with him in the hope that these debates will in no way impede the good work of the rebuilding of the Navy and the re-arming of our sea-coast defenses by adding further confusion to a somewhat confounded subject.

This work of reconstruction as it is now going on is eminently wise and patriotic, and it is a surprise, which I as a citizen take pride in, to witness how much is being done, and well done, at the various navy yards and construction plants by the Army and Navy Departments, when it is considered how little money has been appropriated in the past for this work, and how limited the experience on this side of the water has been in these matters; and any change in the established programme of defense decided on by the proper authorities should come in as additions and reinforcements to the work now under way. To that end every citizen should contribute his influence and help, be it great

or small, until the nation is in a position to defend itself and enforce such respect as is due both to national as well as international law and order.

ADDENDA.

The following late tests have been made on aluminium bronze, and are given as they bear somewhat upon the discussion:

Bar of A_2 metal rolled hot from a two-inch billet down to $\frac{13}{16}$ inch diameter and tested at the Washington Navy Yard.

Tensile strength per square inch of original section, 92,361 pounds.

Tensile strength per square inch of reduced section, 127,755 pounds.

Elastic limit per square inch, 44,299.

Elongation at failure, 28.76 per cent.

Elongation after fracture, 32.74 per cent.

Reduction of area at failure, 27.7 per cent.

Reduction of area after fracture, 38.2.

Dimensions of specimens between measuring points, diameter .561 inch, length 2.85 inches.

Watertown Test No. 4647:

A_2 aluminium bronze that rolled to bar one and one-eighth inches in diameter.

Sectional area of test bar, .25 of a square inch.

Gauged length, 6 inches.

Tensile strength, original section, 89,920 to square inch.

Elastic limit, 50,000 to the square inch.

Elastic extension, .0187 or .0031 per unit length.

Modulus of elasticity, 16,551,700 pounds.

Elongation after rupture, 30 per cent.

Contraction of area, 49 7 per cent.

Hardness, 16.9, taken on the metal that had not been elongated and thereby still farther hardened.

The reserve of ductility in this case shows that cold working would still further elevate the elastic limit.

Watertown Test No. 2469:

A_1 aluminium bronze hot rolled from a two-inch billet to $\frac{13}{16}$ inch round bar.

Sectional area of test bar, .20 of a square inch.

Gauged length, 2 inches.

Tensile strength, 111,400 pounds per square inch.

The report reads: Probable elastic limit 84,000 pounds per square inch.

Elastic extension, .0191 or .0095 per unit length.

Elongation after rupture, 6.5 per cent.

Contraction of area, 6.9 per cent.

Watertown Test No. 2467:

Determination of hardness of A_1 aluminium bronze cast in chill mold. Hardness of piece, 21.17.

The following contribution from the distinguished engineer, R. Van Langhenhove, of the University of Liège, Belgium, was received too late to be presented to the meeting, but is here inserted as a valuable addition to the discussion:*

HAREN, BELGIUM, *October* 18, 1887.

TO THE MEMBERS OF THE NAVAL INSTITUTE, ANNAPOLIS, MARYLAND.

Gentlemen:—I thank you for the kind attention you have paid me in sending me the remarkable work of Mr. Alfred H. Cowles, of Cleveland, on the employment of aluminium bronze as raw material for the fabrication of heavy guns. I will not permit myself either to deny or confirm most of the facts which he has just submitted to your learned criticism, not having had occasion to study as closely as himself the experiments to which he has devoted himself for nearly two years past. Still, having, during 18 months, followed, at a great distance, with the minutest attention, the development of the process of fusion by electricity invented by Messrs. E. H. and A. H. Cowles, I can, notwithstanding a lack of knowledge in the matter of artillery that I do not seek to deny, bring to the debate the balance of my feeble lights to aid in solving a problem, the solution of which all Governments anxious for their independence and for the integrity of their territory have sought and are still seeking every day—the construction of the most perfect offensive and defensive weapons of war.

Not having time to examine the question as to all its conditions, I am forced to sketch rapidly my impressions.

If we consider, first, the fabrication of weapons of war (and by this term I mean more especially guns), we know that a perfect cannon should be made of a metal having the following qualities:

1st. Great freedom from foreign matter;

2d. Great homogeneity;

3d. A sufficient tenacity, in order that, without requiring huge dimensions, it can resist pressures engendered by the expansion of the gases produced by the explosive mixture;

4th. Great hardness, in order to resist the corroding action of the gas products under the influence of a high temperature, and the destructive action of the projectile passing along the bore of either the rifle-cannon or smooth bore;

5th. Not to burst in a manner dangerous to those serving the piece—a quality which has a great influence on the *morale* of those people;

6th. To be produced in a regular way, so as to give to the constructor a certainty of obtaining the quality which he needs;

7th. To be of a suitable price,—for the cost of acquiring the material of war being enormous, it is necessary that gun metal should be of the lowest price possible; and finally,

8th. It is necessary that the raw material for the fabrication of guns should be delivered to the arsenals in quantities equal to the needs.

* Translated by Lieutenant D. H. Mahan, U. S. N.

Let us seek, then, in accordance with this programme, which is the metal that satisfies most completely the qualities therein enumerated. Without entering into the discussion of the comparative values of cannons of wrought iron, cast iron, tin bronze, and steel, we can immediately throw out of consideration wrought-iron cannon, the making of which has been considered in all times absolutely defective, and cannons made of tin bronze, which have been dethroned for many years by those made of phosphor bronze.

Our field of investigation reduces itself, then, to a consideration of cast-iron and steel guns. From the elements of criticism that I possess, it is shown clearly that cast-iron guns suitably made on the system of cooling from the centre of the bore, as for example by Rodman's method, and suitably strengthened by means of bands of iron or steel, have nothing to concede to steel guns made after the most perfect processes; and Mr. Alfred Cowles seems, in confining himself entirely to steel guns simply cast or made of pieces supporting one another,—that which he calls "a built-up gun,"—to neglect too much the modest cast-iron guns, since the length of service of these latter bears honorable comparison with the former.

This is so true that one of our most distinguished steel engineers, Mr. Greiner,* (of whom I shall have occasion to speak later), himself cites, in the following terms, the example of a cast-iron banded gun that was proved at the same time as a steel Krupp gun, and had acted much better: "This cast-iron gun with steel bands has undergone at the depot of Braesschat some comparing proofs with a Krupp cast-steel gun of the same dimensions, and the *results are all in its favor*. Similar trials have already been made in France. In this last country they have for some time adopted, for the large calibres, cast-iron guns rendered more resisting by steel bands placed on hot."

It is not to be denied, however, that cast iron possesses an absolutely insufficient specific resistance. Nevertheless the cast-iron cannon are made of metal in a state of fusion, and consequently the metal of which they are formed possesses as a quality a homogeneity which constitutes its principal merit, and which is as strongly claimed in favor of cast steel.

Metallurgists and artillerymen have naturally been brought to occupy themselves in replacing a metal of feeble tenacity by the, as they say, far more resisting steel; and, thanks to the progress made in its manufacture during the last 30 years, they have procured it for some time past at a reasonable market rate, or, at least, the increase of price has not been made a cause for rejection *a priori* by the artillery board.

As, however, steel is actually the object of the discussion, since it is the only metal employed for the fabrication of heavy siege or defense pieces, I will limit myself, like the author of the remarkable work which has just been read, to the study of the employment of steel and of aluminium bronze for the making of heavy guns.

And, in the first place, what is steel? If we consult the immense works written and published by our greatest metallurgists or our best engineers, we cannot get a precise idea of this siderurgistic product. The works in which I

* Director-General of the Cockerill Works at Seraing, Belgium.

could find the opinion of the siderurgists of your great and marvellous country are not familiar to me, so I wish to cite only the opinions of the authors of the European continent, correspondence with whom is habitual to me.

That eminent authority on steel, Mr. A. Greiner, chief of the important establishment of Cockerill, at Seraing (and whose name I have already mentioned), gave in 1872 a definition for steel, to which he referred three years later only to confirm it, in saying, "They give the name of steel to all those *malleable* products of siderurgy obtained in a *state of fusion.*" He preserves the name of iron for all those *malleable products which have not been in a state of fusion;* and he gives as a parallel scale for the classification of irons and steels the following table:

SCALE OF MR. GREINER.

Series of Irons.	Amount of Carbon.	Series of Steels.
Ordinary irons,	0 to 0.15	Extra soft steel.
Grained iron,	0.15 to 0.45	Soft steel.
Steely irons or puddled steel,	0.45 to 0.55	Semi-soft steel.
Case-hardened iron or steel. Steels of Styria.	0.55 to 1.5 per cent and over.	Hard steel.

Therefore, according to Mr. Greiner, irons and steels can have identical chemical compositions, but only differ from one another by the manner in which they have been treated in the kiln.

Before him, the eminent Austrian metallurgist, Mr. Tünner, had given the following scale, which deviates notably from that of Mr. Greiner:

Number in Classification.	Amount of Carbon.	Qualities.
No. 1,	1.50 per cent.	Mixed steel.
No. 2,	1.25 "	
No. 3,	1.00 "	Tool steel.
No. 4,	0.75 "	
No. 5,	0.50 "	Homogeneous metal.
No. 6,	0.25 "	
No. 7,	0.05 "	Cast iron.

Mr. Greiner finds, then, that iron not containing one atom of carbon is steel if it has been obtained by fusion.

He has, however, obtained from a great number of metallurgists, amongst others Mr. Jordan, the learned French engineer, entire approbation; but, on the other hand, he found in Mr. Grüner, Inspector-General of Mines in France, a declared adversary.

The latter calls steel, "all metal malleable both hot and cold and *capable of being tempered,* intermediary between the soft iron, malleable both hot and cold but not susceptible of being tempered, and cast iron, not malleable but susceptible of being tempered by a sudden cooling."

Before them Mr. Karshen had said: "Steel is a hard metal, ductile, less easily welded than iron, and above all, more fusible as its property of being welded diminishes."

Finally, Mr. Percy says: "The carbon is present in certain proportions; and within limits which cannot be *exactly* fixed, there are these different varieties of steel—very elastic, malleable, ductile, easy to weld and forge, very tenacious, fusible at high temperatures."

To sum up the difference between the opinions of the authorities I have just cited:

A. For cast iron and steel. 1. According to Messrs. Karshen and Percy, the malleable and welding qualities. 2. According to Messrs. Greiner and Grüner, malleability.

B. For iron and steel. 1. According to Mr. Karshen, the welding and fusing qualities. 2. According to Messrs. Grüner and Percy, the temper. 3. According to Mr. Greiner, the fusion or the melted state.

If, then, it is a metal which complies with such an elasticity of valuation that it is iron even at 0.6 per cent (Percy) of carbon, and that it is steel when it contains none of it, what can we conclude from what precedes, except that it is not a metal, precise, determined, special, but an alloy of iron and carbon? And in fact, from the fusible casting containing six to seven per cent of carbon, up to the iron in a melted state, the scale is so vast that any other definition seems impossible. In fact, no one can state where steel commences or where it ends, although it is certainly known that when it is surcharged with carbon it is no longer steel, but iron. I have said it was an alloy. An alloy it is, in the same category with the alloys of copper, tin, zinc, silicon, aluminium; and according to the proportion more or less great in which it is united with charcoal (I do not say combined), it possesses or takes different properties, just as the combined metals communicate to the copper with which they unite or combine qualities which depend on the percentage of metal added. But if the steel is an alloy of iron and carbon, it is so much the more an alloy of an absolutely unstable nature. When one sees a metal take properties so different, according to the percentage of carbon, that a few hundredths causes it to pass from a soft to a hard state, what confidence can one have in it for the construction of large pieces of artillery (for, gentlemen, it is only with that point in view that I discuss the value of steel), in which the conditions of regularity, of homogeneity, and of security are primordial, absolute, indispensable?

Instead of following, in the employment of steel (in a crude state) for the manufacture of cannon, an immutable method and fixed rules, we see that the employment of the metal depends upon an opinion more or less special according to the views of the operator. It is no longer a law which guides the constructor, it is his good pleasure, it is his personal opinion, more or less reasoned out or based on an experience more or less great—in a word, it is feeling one's way.

And, in fact, what do we ascertain in practice? Let us see, for example, what happens at the Arsenal at Woolwich, that universally renowned establishment. There private industry finds a free path and furnishes to the state the raw materials which are used in the manufacture of cannon—and what do we ascertain?

The following tables which Mr. Greiner gives us will enlighten us completely on this subject:

Origin.	Number of block.	Carbon.	Manganese.
Firth, ...	5592	0.338	0.075
	5614	0.400	0.126
Whitworth, ...	5607	0.300	0.312
	5658	0.417	0.240
Vickers, ...	5761	0.240	0.216
	5759	0.272	0.225
Cammell, ...	6067	0.143	0.341
	5889	0.194	0.248

There is the raw material! No rule, no law—a chemical composition eminently variable, its components varying from 0.075 to 0.341 for manganese, and from 0.143 to 0.417 for carbon; and this is the metal which is going to be worked up to make homogeneous pieces! There is shown in the following table the products obtained:

Origin.	Natural State.			Tempered at Low Temperature.			Tempered at High Temperature.			Remarks.
	Limit of Elasticity.	Breaking Strain.	Elongation.	Limit of Elasticity.	Breaking Strain.	Elongation.	Limit of Elasticity.	Breaking Strain.	Elongation.	
	Pressure in kilograms per square metre.			Pressure in kilograms per square metre.			Pressure in kilograms per square metre.			
	per ct.	per ct.	per ct.	per ct.	per ct.	per ct.	per ct.	per ct.	per ct.	
Firth.....	18.60	48.05	23.04	49.06	75.90	23.69	48.18	63.91	13.62	Breech.
	17.05	45.57	17.27	57.24	82.99	28.77	60.48	89.17	9.59	Chase.
Whitworth.....	22.41	52.16	23.54	54.22	80.92	12.53	54.69	81.09	12.48	Breech.
	22.21	50.80	23.16	54.66	80.11	11.97	54.54	80.40	12.75	Chase.
Vickers.....	18.29	47.36	24.26	45.04	70.46	14.05	46.21	71.68	14.49	Breech.
	22.53	51.79	14.09	54.95	79.15	7.07	55.39	77.28	7.16	Chase.
Cammell.....	21.54	43.99	27.20	54.92	67.72	14.05	46.64	68.94	12.70	Breech.
	18.94	41.92	28.70	50.45	72.71	12.95	53.01	75.77	11.80	Chase.

No fine phrases are needed in drawing a conclusion from the two preceding tables, when we find such very different metals as those furnished by the firm of Cammell, which contain only 0.143 and 0.194 of carbon, comparing in tenacity and elongation after tempering with the steels of Firth, which contain 0.338 and 0.400 of this metalloid. For alongside of this metalloid we see the metal manganese play an important part, strengthening my previous conclusions that steel for cannon is an alloy, and this time not simple but composite, in which silicon, sulphur, and phosphorus play a part alongside of carbon, and in which manganese in its turn intervenes in order radically to defy the theories expressed by the learned engineers whom I have named.

I do not wish to wear out your attention by mercilessly following the action of steel as a metal for guns, but I have said that the steel alloy or cast steel which serves for the construction of pieces of large calibre is an alloy of a nature eminently unstable, and I prove it. It is impossible, in fact, to use this cast metal for an ingot mold or for a mold for the manufacture of cannon of

considerable weight. The enormous masses produced by the casting (tapping) have in themselves a chemical and molecular composition absolutely variable, and this variableness is increased so much the more as the mass is increased.

Steel prepared for the manufacture of cannon should be fine grained. If the fracture shows fine grain the steel is practically of good quality. It possesses then the requisite tenacity, supposing that all the other influences destructive of that tenacity have been eliminated. If the fracture shows coarse grains or crystals the product is defective and the piece of a poor quality.

Now, as an absolute opinion, the irregularity of crystallization cannot be completely overcome during the process of casting very large pieces. It is the forge that is destined to bring about as great a uniformity as possible. Forging, however, whilst approaching that end, does not attain it. In fact, these enormous pieces of steel which after being worked are suitable for constructing cannon, require to be heated to high temperatures for the forging. The more that temperature is raised, the more sensitive the metal is to the action of the gases in the furnace and the more rapidly its chemical composition changes. It loses little by little its carbon and is converted slowly into iron at the surface, whilst the centre remains intact. We have then, at the moment when the ingot is carried to the hammer, a mass at a high temperature whose particles are separated by a distance which depends upon the degree of heat, and which the force of the hammer does not succeed in reducing until the moment when the powerful heat diminishes; so, through the cooling and the uninterrupted hammering, the mass has not time to crystallize, but is found after complete cooling to possess the tenacity and the homogeneity sought for, provided, always, that the chemical combination remain the same throughout the mass.*

But Mr. Jordan says: "The large forged pieces, the plates which pass several times through the furnace to be reheated and which cool slowly at each heating, are apt to crystallize under the repeated blows of the hammer in the central parts *which the shock does not reach*, and in fact do *crystallize at the core*. In order to remedy this and prevent ruptures following these cracks, it is necessary, when the piece is completely fashioned, not to allow it to cool to the centre, but to replace it in the furnace until the exterior is red hot, after that to bring back the iron by tempering it in water, which may be warm for the little pieces but cold for the large pieces like the plates, for example; *without that precaution* an armor plate of good soft iron *would break* into large pieces under the shock of the ball *instead of resisting it*." In fact, then, to attain the double end—preventing the molecular modification as well as the chemical modification—is impossible, for the metal changes from the periphery to the centre, from the moment of the casting up to the reheating in the furnace during the forging, owing to the action of the furnace gases or atmospheric air, or to the mode of cooling.

Moreover, the ingot of steel, from its casting to the moment when it is taken to the furnace for refining the metal and warming it for shingling, contains

* Tchernoff, director of the steel works of Obankoff (St. Petersburg), in a note communicated to the Imperial Technical Society of Russia.

always and inevitably, scattered through all the mass, an enormous quantity of blisters or cavities filled with cracks, scoriae, or air, which never disappear completely, notwithstanding the energetic hammering under the weight of powerful machines. I stop this statement here, since time forces me to keep within narrow limits, and in order not to vex the staunch defenders of steel "metal." I will admit that steel is in fact a very elastic, malleable, and ductile alloy, easy to weld and to forge, very tenacious, and fusible at high temperatures; but this is only the case when one works carefully on ingots of particular dimensions (generally small), when they are made of a pure homogeneous metal, free from flaws, cavities or cracks, and of a fine regular grain, and when forged and hammered thoroughly in such manner as to preserve at the surface as well as at the core a regular chemical composition and molecular disposition.

But if heavy masses are worked, the finished product will only be an uncertain object, the uncertainty arising (1) from the difference between the chemical composition and the molecular cohesion of its parts; (2) from material irregularities arising from a work that can never be brought to perfection; (3) from differences in the tenacity of the metal, arising from variations produced by tempering; (4) from the impossibility of working up an exact, homogeneous metal, free from cavities and flaws.

My conviction, based on the study of the physical properties of the metal itself, is considerably fortified if we pursue our examination by the study of the manufactured object,—produced by means of the systems so much in vogue a short time ago, but upon which the opinion of men of science is now reversed,—called Krupp guns, Armstrong guns, etc.

Mr. A. Cowles has demonstrated to you, simply but clearly, the inconveniences arising from the manufacture of built-up pieces. This demonstration is sufficient to convince the most incredulous, and he might have ended by saying, with one of your distinguished compatriots, Mr. W. Metcalf, of Pittsburg, that when the cannon fashioned after the system called "built up" is finished, "*it is only a mass without scientific or mechanical value, and of a resistance absolutely uncertain.*"

I do not wish, before an assembly so competent as yours, to re-open the chapter of accidents and disasters published in the newspapers (as I write I learn that the large cannon of the de Bange system which has figured at the Universal Exposition at Antwerp has just burst), and enumerate the dreadful but too numerous disasters which have occasioned the death of so many intelligent and brave officers and unfortunate soldiers—without counting the losses of material—the number of which suffices to prove the necessity of removing from the field of battle, both on land and sea, these engines which seem to be as fatal to those who manage them as to those against whom they are turned.

Neither will I dwell on the enormous cost of manufacturing these pieces, a cost occasioned entirely by the unstable, unknown, and puzzling nature of this metal which no one can master, and in the handling of which one cannot take too much care; which requires expenditure of much money and time, the employment of the largest and most accurate tools, and makes necessary a large plant, great space, and considerable capital to bring it within determined limits, limits that are attained only by a mere chance.

In fine, to wish to produce a metal which, in a suitable state of purity and finish, ought regularly to sustain a resistance of from 10 to 12,000 kilograms (9 to 11 tons) per square centimetre, but which, after having been confided to the most clever and experienced workmen, after having received the greatest care, after having been heated in furnaces built with all the science of the engineer, and after having been compressed under trip hammers of 50, 80, and 100 tons, only gives a resistance of from 3 to 4000 kilos per square centimetre, and will often burst at the first firing—this is no longer progress, it is retrograding; it is no longer science, it is blindness!

In conclusion, I say that a metal of a natural resistance of 10 to 13,000 kilograms per square centimetre, which only gives, after the considerable manipulations to which it has been submitted and which increase its value twenty times, a result three times less than the maximum, is a metal that ought to be condemned.

I will only say a word on the subject of aluminium bronze as a metal destined to replace steel and cast iron in the construction of all pieces of artillery, from the smallest to the largest.

Do not believe, gentlemen, that the statement of the advantages of aluminium bronze which has just been shown to you with so great moderation by Mr. Alfred Cowles, is of a recent date, and is caused only by the introduction on the metallurgic markets of numerous and remarkable alloys due to the invention of the reduction of minerals by the electric furnace. This application of aluminium bronze was predicted long ago by Mr. Weber, Colonel of Artillery, director of the Royal Foundry at Augsburg, Germany, soon after the happy invention of the process by Mr. St. Clair Deville.

In 1859, 28 years ago, Colonel Weber stated that aluminium bronze resisted a pressure of 6820 kilograms (per cubic centimetre), whilst tin-bronze cannon did not resist more than a pressure of 2784 kilograms (per cubic centimetre), a resistance obtained by great care and extraordinarily minute work.

Even at that time, gentlemen, he made a comparative estimate of the cost of cannons made of aluminium bronze and tin bronze, and notwithstanding that the price of aluminium was then 10,000 francs for 100 kilograms (2000 dollars for 220 pounds), he found for the first a price of 1308 francs for 100 kilograms, and for the second 318 francs only. Notwithstanding this difference in price (4 to 1), he recommended the employment of aluminium bronze cannon. To-day the metal of the Cowles Company sells on the market for about 450 francs per 100 kilos, that is to say, at one-third the price it was thirty years ago.

The prophecy of Colonel Weber should then be realized with more certainty to-day than then, for, besides a considerably lower price and greater abundance for the manufacture of weapons of war, the metal, prepared without the numerous chemical manipulations of the process of St. Clair Deville, proceeding from purer ores, and alloyed with first-class copper, should resist,—and experiment proves in fact that it does resist,—much greater strains than at that time.

I cannot dwell on the physical properties of aluminium bronze, but we know how resisting that alloy is, what great ductility it possesses, with what marvel-

lous facility it invariably casts, that it is exempt from cavities and flaws, and possesses an astonishing homogeneity and regularity of composition. Its chemical composition and molecular disposition do not vary throughout the mass. Its low point of fusion permits it to escape treatment under the influence of high temperatures, thus removing one of the disadvantages so disastrous to steel. But it can be asserted that, strong, resisting, homogeneous, compact, regular as is aluminium bronze, it will be possible to reduce the weights of metal considerably in working it, to obtain equal results. For there is no use dissimulating; in order to produce steel cannon of determinate power, it is practically necessary to give it a much greater weight than that absolutely required—and yet we know the result arrived at.

It is not necessary to take such precautions with aluminium bronze. And likewise, the dimensions of pieces made of a metal regularly obtained can be exactly calculated, and they can be constructed without giving more weight to them than the coefficient of safety indicates; at the same time a cannon in aluminium bronze can be made of much smaller dimensions whilst obtaining the same result. Consequently, the comparison between the prices of steel and aluminium bronze, such as has been furnished to you by Mr. Alfred Cowles, will increase notably in practice.

I regret that time is wanting to give to this interesting subject the development that it deserves. But I close, gentlemen, by thanking you for your kindly attention, and I doubt not that the issue of the discussion to which you apply yourselves to-day will be favorable to the new practical metal which the marvellous invention of the Messrs. Cowles has called to the attention of the intelligent world.

R. VAN LANGHENHOVE,
Engineer of the School of Mines, Arts, and Manufactures, annexed to the University of Liège.

The following letter bearing upon this discussion was forwarded by Mr. Cowles, and is here published with the consent of the writer:

ROSE POLYTECHNIC INSTITUTE,
TERRE HAUTE, IND., *November* 3, 1887.

My dear Mr. Cowles:—I have hoped to find time to answer your letter earlier and at greater length, but a press of other occupations has prevented. I read your paper on aluminum bronze with great interest, as I have watched with great interest your development of the process of its manufacture. I am and have been convinced that you have done a good thing; good for others, and I hope it will prove to be good for yourself. As far as I can see, your arguments in the paper are sound, and I think you have made a very strong case.

I think there can be no question that there is greater danger from "explosive bursting" where there is a lack of continuity in the structure of the material, as in "made-up" guns, than where continuity exists, even if homogeneity does not, other things being equal. While reading your paper I could not but think of an illustration of this, drawn from a subject to which I have given a

good deal of thought for several years. I refer to the destructive effect of earthquakes. Whenever an earthquake wave strikes a structure which is *lacking in continuity*, as a building of brick or stone, or both, the destruction is much greater than it is where the parts of the structure are so framed together as to make them practically one. The latter form is often seen in a well framed Japanese house, in which the timbers are *pinned* together, so that the building vibrates as an elastic whole. In a "made-up" gun the effective strength must often be only that of a single band or cylinder, unless the greatest precision is used in its construction. The reflection backward of a wave at a surface of separation is an established fact in physics, and I see nothing unreasonable in your hypothesis that to this may be due, in some degree, the rapid crystallization of the material. I think you can "defend" your thesis with good reason, and I have no doubt you will succeed in so doing. If not too much trouble, I would be glad to receive a few specimens of your bronze—for our cabinet—and to be referred to the best published description of its preparation.

I hope to hear of any improvements which you are making, and beg leave to subscribe myself, Yours faithfully,

T. C. MENDENHALL.

Mr. Alfred H. Cowles, Lockport, N. Y.

NOTICE.

It is proposed to continue the discussion of Aluminum Bronze for Heavy Guns in the early part of February next at the Newport Branch, at which time the Cowles Brothers expect to be prepared to present additional proof of the suitability of their alloy for gun-metal. The exact date of the meeting will be announced later in the service journals and by circular letter.

Those desiring further information in regard to the meeting will please address Prof. C. E. Munroe, Corresponding Secretary, U. S. N. I., Torpedo Station, Newport, R. I.

CHAS. R. MILES, *Lieut., U. S. N.*,
Secretary and Treasurer.

PROFESSIONAL NOTES.

OUR COAST DEFENSE, ITS COST, AND ITS MECHANICAL PROBLEMS.

(A REVIEW.)

A paper by Joseph Morgan, Jr., with the foregoing title, and the discussion of the same published in the current volume of the *Transactions of the American Society of Mechanical Engineers*, contains so much of interest to the members of the Institute as to deserve more than a passing notice. Mr. Morgan, in consequence of his investigations as one of the civilian members of the Fortification Board, has fully equipped himself for an intelligent treatment of the subject in hand; and he deserves much credit for bringing the mechanical problems of defending our coast to the attention of such a progressive and influential body as the American Society of Mechanical Engineers. We believe it is by continually presenting the subject in this way, and thus arousing a strong public sentiment against the present unwise abandonment of our sea-coast to the possible ravages of an enemy, that Congress may be brought at no distant day to grant liberal appropriations for the national defense.

In the introduction to his paper Mr. Morgan says: "This paper is intended to open a discussion on coast defense, and to call attention to important facts which should be familiar to every one, or about which there appears to be misinformation." He then proceeds to the consideration of the cost of putting the coast in a proper state of defense. In this connection he says that the cost as estimated by the Fortification Board, for 27 ports, was $126,377,800, to be expended at the rate of $11,000,000 annually for a period of 12 years, this being at the rate of about $2.52 per head, reckoning the population of the country at 50,000,000. This, he estimates, "is barely 2 per cent of the value of the destructible property of these cities, or about the premium paid for ordinary fire insurance on a good risk for a three years' policy."

Mr. Morgan, in answer to the question, "Why should our defenses remain obsolete?" says: "Apply to this question the judgment which a manufacturing concerns applies to its business. Would a management with good sense neglect to put in new plant, and allow its factories to remain filled with machinery of capacity unequal to competition with other plants springing up around it? Such a concern would soon go out of business. We should have defenses complete with all preparations necessary to defend our shores from any force, land or naval, which may be brought against us. Proper means being provided, we would be able at short notice to beat off an enemy with little cost to ourselves, with great damage to him, and small chance of success on his part."

It will be well here to insert from Mr. Morgan's paper a few extracts that bear particularly upon the naval part of the defense of the coast:

"It is perfectly feasible to-day to land a force on our shores. It would, however, be impossible to maintain such a force, except in close communication with some convenient port occupied as a base of supplies. To prevent such occupation and the levying tribute upon our great coast cities is the object of our coast defense, or, to quote Bernard and Totten's report, 1826:

"'Fortifications must, 1st. Close all important harbors against an enemy and secure them to our military and commercial marine.

"'2d. Deprive an enemy of all strong positions where, protected by naval superiority, he may fix permanent quarters in our territory, maintain himself during the war, and keep the whole frontier in perpetual alarm.

"'3d. Cover the great cities from attack.

"'4th. Prevent, as far as practicable, the great avenues of interior navigation from being blockaded at their entrance into the ocean.

"'5th. Cover the coastwise and interior navigation by closing the harbors and the several inlets from the sea which intersect the lines of communication, and thereby further aid the Navy in protecting the navigation of the country.

"'6th. Protect the great naval establishments.'

"It is taken for granted the proper line of impassable defense is not an offshore fleet. Although a naval officer is quoted as saying, 'We need no forts, but our coast defense should be intrusted to a navy,' his position is erroneous. A navy to protect our extended shore of over 4000 miles, and ready to meet a squadron of the enemy anywhere on the coast, means a powerful fleet at many points, and involves an outlay immensely greater than coast fortifications. To meet a possibly superior naval force and join it in battle with no alternatives but victory or destruction afloat, followed by surrender ashore, is not the task to be given to our naval force.

"'The Navy should be free to seek the high seas,' to accept the issue of battle when victory is possible, to destroy commerce of the enemy, to harass the flanks of a superior force, cut off its supplies, and, when close pressed, find, under powerful guns ashore, an efficient shelter. It should be a flying column, not tied to a harbor defense line, but free to go even to the enemy's own shores and thus keep his fleet at home. It should be powerful enough, when concentrated, to break up a blockade of our important ports.

"To permit this concentration of the naval force, the defense of any port must be complete without a navy. A navy may assist, although it should not be essential to the defense. It can follow up crippled vessels, destroy them after repulse by fortifications, and make defeat in attack a total ruin to the enemy.

"The defense of harbor entrances by guns afloat, exposed to destruction from shot and torpedoes, and mounted upon the most costly, complicated and delicate of gun carriages, a steamship, is an expedient only to be adopted when other locations for the guns are not available.

"This is not the age of chivalry, when one offers an enemy equal terms of battle, but the age of science and mechanism, when results are calculated, and we offer an adversary destruction if he accepts battle on our prepared ground. The defense, therefore, should be, when practicable, at the harbor mouth, by permanent works. To be complete and impregnable, there must be obstructions in the channel, to prevent a run by, and powerful guns ashore to keep the enemy's fleet from removing the obstructions or quietly anchoring and bombarding cities near the shore without danger to themselves. There must be obstructions because 'modern ships of war with high speed and heavy armor can pass any shore battery if the channel be clear.' There must be guns, otherwise the enemy will destroy the torpedo obstructions by countermining. The guns must be heavy, for while light guns would prevent countermining by unarmored vessels, the heavy armored vessels would proceed with this work, unless prevented by armor-piercing guns on shore. . . .

"For flanking guns to prevent unarmored vessels and small boats fishing up or countermining torpedo obstructions, our present forts with present guns and a few machine guns will answer. A fleet of harbor torpedo boats should also be available to assist in making the torpedo defense dangerous, should the enemy, at night or in fogs, attempt countermining or removal of torpedoes. These boats would also make blockades dangerous, or compel the enemy's squadron to haul off coast at night. They may be, say, boats of 100 feet length; speed, 21 knots per hour. There should be enough of them built at once to

train our engine and boat builders, to bring the special knowledge required, and to have the plans and details well developed. Then, in case of necessity, these small engines could be turned out in numbers from our numerous shops, trained to do good high-speed engine work, and the hulls could be built anywhere and transported by rail or canals to our lakes and harbors. The Fortification Board recommended the building of about 160 of these torpedo boats, to be distributed to various ports; New York, San Francisco, Boston, Hampton Roads, New London, Portland, Oregon, to have 18 each; New Orleans, 12; Philadelphia, Portland, Maine, Narragansett Bay, Key West, and Charleston, 6 each; and lake ports, 12 torpedo gunboats.

"Another item in the scheme of coast defense is floating batteries, for which five ships, three at San Francisco and two at New Orleans, are estimated at a cost of $19,000,000. At San Francisco the depth of entrance and strength of currents prevent the use of torpedoes. At New Orleans, near the heads of passes where torpedoes must be, no foundation can be had for heavy gun protection on shore. The vessels designed for this are superior in armor protection and offensive power of guns to any now afloat.

"The report of Commander Sampson, United States Navy, of Fortification Board, upon the proper use of navy and floating batteries, is a very interesting and able one. Of the whole $126,000,000, however, estimated as necessary to defense, over $94,000,000 are for forts and for armament of heavy guns." . . .

In regard to the view thus presented by Mr. Morgan respecting the part to be taken by the Navy in the defense of the coast, Lieutenant-Commander F. M. Barber, U. S. N., in his discussion of the paper, makes the following timely criticism:

"I am aware that this view is thoroughly indorsed by the report of the Fortification Board, of which he [Mr. Morgan] was a member, and I would not like to be understood as undervaluing the recommendations of the Board in so far as the kind of defense they recommend is concerned; but, in regard to the quantity of floating defenses and the part that must necessarily be taken by the Navy, their position is not a strong one. I am particularly anxious that I should be correctly understood in this matter, for I well understand the evil effect of officers criticising each other's reports where the appropriation of money is involved, as it confuses the public. Nothing that I have to say would alter the specific use of a dollar from the purpose for which the Fortification Boar would apply it. They have recommended none too many defenses at anchor; but they have not protected those at anchor with enough that move. 'The Navy should be free to seek the high seas,' as the paper says; but its freedom to do so should depend upon the fact that it has enough ironclads and torpedo boats (surface and submarine), with officers and men to man them, still remaining to do their share in protecting the coast. In these days of torpedo warfare, I take the broad ground that the defense of no port can be complete without the Navy. Not only it *may* assist, as the paper suggests, but it *must* assist, and it is absolutely essential to the defense. No coast can be properly defended, according to the ideas which I believe are most prevalent in Europe, without an outer line of ironclads, an inner one of gunboats and torpedo boats, and lastly, the fixed defenses at the bottom of the harbor and on the shore. The officers and men of the Navy have unquestionably the particular kind of education which adapts them to the two lines afloat, and torpedoes fixed and movable have caused such a gradual crawling down of all the live defenses of a port, off the land and into the water, that more and more aquatic knowledge is necessary, and in Europe this whole matter is gradually drifting bodily into the Navy, forts and all. In Germany it is already done. In France, coast defenses are in an amphibious state, and in England, judging from the discussion of the paper of Colonel Schaw, of the Royal Engineers (Deputy Director of Fortifications), read before the Royal United Service Institution in December last, the necessity of some kind of combination of the Army and Navy is recognized and its consummation is probably a matter of the near

future in England. One of our most prominent army torpedo experts once told me that he could see plainly the desirability of some such arrangement in order to obtain a more perfect knowledge of the value of fixed mines with reference to their location. Said he, 'I know what *I* think a navy-man would do if he had to attack any harbor; but I would very much like to know what *he* thinks he would do.'

"As Viollet le Duc argues in his *Annals of a Fortress*, 'the proper place for defense is at the outworks, to harass, discourage, and demoralize your enemy, and prevent work on his system of approaches.' But this only enhances the value and necessity of a stronghold which you know is always in your rear, and to which you can retreat from time to time, but which could scarcely be made so formidable that a modern fleet could not pass it eventually, if the approaches were once clear and could be kept so. Guns and electric lights on shore would not sufficiently protect the submarine mines at the bottom of the harbor. Co-operations of army and navy will probably be the solution of this problem in our country, and the horse marine will become a living actuality.

"The Fortification Board recommended but 160 torpedo boats for our enormous stretch of coast (it is 12,000 miles instead of 4000, if we include the lakes and Alaska), while Germany is building to-day 150 torpedo boats for her exceedingly limited coast line. The Board recommends but five armorclads, three for San Francisco and two for New Orleans. It is true, as the paper says, that they are the most expensive gun carriages in the world; but they are movable, and while the Board provides fixed protection for the principal ports on our coast, it makes scarcely any provision for the coast between the ports. To fortify strongly only important places is an open invitation to an active enemy to effect a landing at the unimportant ones, and it should be remembered that, unlike Europe, we have no inland fortifications whatever in our country. Cost what they may, movable defenses must be had, and their power of concentration on any point attacked renders them far cheaper than a continuous line of strong fixed defenses.

"The following information, from reliable sources, shows the growing importance of the navies of Europe in connection with the problem of coast defenses.

"GERMANY.—The sea-coast defenses, torpedo boats, torpedoes, submarine mines, etc., of Germany, have been placed in charge of the Navy. The Navy Budgets of 1885–86 provide for the expenses of maintaining torpedoes, torpedo boats, and submarine mines, and of the necessary personnel to manipulate them.

"The fortifications have recently been transferred from the Army to the Navy, and the following reasons have been assigned for this transfer:

"The forts at the mouth of the Elbe, in addition to those at Kiel and Wilhelmhaven, have been transferred to the Navy, and are garrisoned by the third battalion of Marine Artillery, which has been added to the existing force for this purpose. These battalions are officered by line officers of the Navy, and the non-commissioned officers are seamen-gunners. Three-quarters of the privates are gunners from the Navy, and the rest come from conscription district in the neighborhood. The change was made on the recommendation of the Minister of War, approved by the General Staff and Military Cabinet of the Emperor, for the following reasons:

"First. Because the guns and carriages are similar to those used in the Navy.

"Second. As this defense is chiefly against attacks from ships and naval landing parties, seamen would more readily appreciate the points of weakness, objects of manœuvres by the movement of the ships, and recognize the probable designs of the enemy from the preparations.

"Third. That, as the defenses were considerably made up of turrets moved by steam or hydraulic power, a class of men became necessary for the manipulation of the machinery which did not exist in the Army.

"Fourth. That seamen are better adapted to care for works situated in the

mouth of rivers, and would co-operate with submarine defenses more advantageously.

"Submarine defenses of all kinds have been placed entirely in the hands of the Navy. They formerly belonged to the Engineer Corps of the Army, but were transferred to the Navy for similar reasons to those given for the transfer of the coast defenses.

"An Imperial order of March 16, 1886, prescribes the duties of the Board of Inspection for Torpedo Affairs of the German Navy; and all defenses of ports and harbors are to be arranged with the approval of the Chief of the Admiralty.

"The submarine coast defense, as organized by the German Admiralty, distributes the available torpedo boats to different districts on the German coast; each district has a torpedo depot, and the amount of torpedo armament of each district depends on the extent, importance, and vulnerability of the district to be defended. The last fortifications remaining in charge of the Army were the forts at the mouth of the Weser, and, by the Imperial order of November 25, 1886, these were transferred to the Navy on April 1, 1887.

"FRANCE.—On the 6th of March, 1886, a ministerial decree created an additional department in the Ministry of Marine, called the Direction (Bureau) of Submarine Defense. This Direction has control of all torpedoes, mines, and apparatus used in connection with them, and all torpedo boats. The Director of Submarine Defense is a rear-admiral, and the service in each port is divided into two sections: 1st. The *défense mobile*, consisting of all torpedo boats and torpedo store-ships; 2d. The *défense fixé*, having in charge all submarine mines, electric search lights and torpedoes operated from the shore, harbor boats carrying spar torpedoes, care of material, mine boats, etc. The commandant of the *défense mobile* in each fort is a commander in the Navy; that of the *défense fixé* is either a commander or lieutenant in the Navy. A French 'Fortification Board,' organized in December, 1886, consists of five naval officers and five army officers.

"ENGLAND.—In England the fortifications and submarine mine defenses are under the control of the Army. The torpedo boats are all under naval control. The question of turning over the command of the sea-coast fortresses to the Navy, and making the latter completely responsible for the defense of the coast, is under the very serious consideration of the British authorities, and the matter is now being discussed between the War Office and Admiralty. It is proposed by the former that the latter shall have entire control, it having come to the German and French view of the subject of coast defense.

"ITALY.—The Direction General of Artillery and Torpedoes of the Ministry of Marine (chief a rear-admiral), in addition to the manufacture and purchase of material, is also charged with the submarine defense of the coast. The Navy is exclusively charged with all that relates to the naval and submarine features of coast defense, including light batteries of guns which may be erected to command lines of fixed torpedoes and prevent the operations of the boats of the enemy, and the surveillance of the coast and its electric lighting for military purposes.

"The general plans of coast defense are studied and drawn up by a mixed commission of army and navy officers. In the projected scheme of coast defense it is intended to assign from three to eighteen torpedo boats to each of the ports of importance, twelve to fifteen in number. Palermo and Naples will be dependent on the fleet for defense, as they can be bombarded from the open sea (so can New York). The general staff, whose chief is the President of the Superior Council of the Ministry of Marine, forms a separate bureau, without administrative functions. It is charged with the study of all that relates to the organization of the maritime forces, the plans of campaign, the defense of the coast, and questions of naval tactics and strategy.

"It is proposed to organize a special corps for coast defense, to be officered by the older men of the several grades of the line officers of the Navy; men

whose age entitles them to be withdrawn from active service at sea, and who, for the same reason, can best be spared. The corps will have all or a part of the coast defense batteries.

"This project is advocated for two reasons: first, to enlarge the sphere of the Navy in the defense of the coast; second, to stimulate promotion. In the event of its creation, the corps of the coast defense will be charged with the duties of the maritime conscription for recruiting the Navy.

"It is also proposed to form a naval reserve of men under forty years of age, to take part in the coast defense."

Mr. Morgan's views in regard to our present system of gun construction are familiar to our readers through the part taken by him in the discussion of Mr. Dorsey's paper, "Steel for Heavy Guns," published in Whole No. 40 of our Proceedings. But as he has perhaps thrown further light upon the question in his present treatment of the subject, a few extracts will be here quoted:

"Of the various details of defense, none have been the cause of so much debate as the construction of the guns and the material of which they shall be made. The Congress committeeman has the lobbyist always with him, and the steel-casting Rodman advocates, the cast-iron gun contractors, the patent gun inventors, and other interested parties have been sufficiently numerous and active to counteract the wisest counsels of our ordnance officers, so that to-day all work upon army ordnance is at a standstill.

"There are symptoms, however, that the cast-iron men are getting tired, and we shall hereafter hear little of the possibility of making a large, high-powered rifle gun of cast iron. The great 12-inch cast-iron rifle at Sandy Hook is practically *hors de combat*, from erosion of the barrel, although only about one hundred and forty rounds have been fired from it. With 54 tons weight it has only the same muzzle energy as a 10½-inch steel gun of 32 tons weight. . . .

"If guns or gun steel can be made equal to the present specification by casting, let them be accepted, but the standard must not be lowered to reach material of a lower grade; nor can casting makers ask the Government to demand higher qualities for forging than for casting.

"No American engineers can put themselves on record as asking for material of low ductility to be put in guns. The engineering work of this country has never been done on a lower standard of excellence than that of the English, French, or German engineers. The makers of steel castings have, so far, failed to make the quality of steel found in forgings, and the task is, apparently, hopeless. . . .

"The question whether we should forge or cast gun material can be left to the commercial test of cost of manufacture, with every chance that the forge will live and grow fat, whilst the foundry will die of starvation. . . .

"The beneficial effect of mechanical work upon a cast steel ingot, in making it higher in elastic limit, higher in ultimate strength, and much more ductile, cannot be denied. This improvement in quality has not yet been obtained with certainty in any other way than by forging. Of a dozen of steel-casting makers doing a commercial business in this country to-day, I do not believe one will undertake to produce a 6-inch gun tube unforged, of quality equal to United States ordnance specification. They will say the ductility and elongation asked for are not necessary in gun material. If this be so, then raise the powder pressure and the elastic limit, and so increase the efficiency of a given weight of gun and projectile. There is no place for inferior metal in gun construction. The best that can be had is always the cheapest. The steel-castings gentlemen say they can make guns much cheaper by casting than by forging. This is important, if true. It will hereafter be shown in this country, as has already been proved abroad, that the cheapest way to produce gun material is to forge from an ingot of the simplest possible shape. Meanwhile, the armament of this country is delayed, while steel-casting enthusiasts search for a cheap way over ground where 'No thoroughfare' has already been written."

We quote here in full Mr. Morgan's remarks on the subject of armor:

"The question of armor also opens a wide field for debate. Shall it be soft wrought iron, iron and steel compounded, all steel, or chilled cast iron? If a forged material is adopted, the reasons for preferring steel are:

"1st. From the small number of times the material is worked, it is certain steel will be cheaper to manufacture than piled wrought-iron material, which taken from the muck bar, cannot be properly massed together with less than five or six reheatings and weldings.

"2d. There are great possibilities of improvement in the manufacture of steel armor, which has so far only been made for a few years and by one concern, and there is reason to hope, with experience of many concerns and a longer time applied to the manufacture, there will be great improvement in its quality. That there can be much improvement in that of wrought-iron armor seems improbable.

"3d. That it is likely soft and hard steels can be compounded in the same plate successfully, which so far has not been done.

"4th. That steel armor, as now made, is at least equal to iron and steel compounded.

"At the time the report of the Fortification Board was made, a trial of chilled cast-iron armor with very heavy guns had not been made, but the trials of Gruson chilled armor at Spezzia, about a year ago, was an event of the greatest interest to the military engineer. A plate of 87 tons weight and 3 to 4 feet thick was subjected to 4 point-blank shots of the 100-ton 17-inch gun with 826 pounds powder, and projectile of 2205 pounds, striking velocity 1765 feet, and energy 47,500 foot tons. The angle of incidence of projectiles was about 40°. The shots were broken up into small fragments. Any one of the shots would have pierced 31 inches of wrought-iron plate; the fourth heavy shot struck nearly in the same place as the second. The plate was, of course, somewhat cracked, but small pieces only having dropped off from the interior, it was considered to have passed the test condition, which was that no fragment should be detached from inside by blow of shot. Full description of the trial is found in the London *Engineer*. The Krupp steel shot that were fired on this trial are said to be equal to perforation of steel plates of 1¼ to 1½ calibres without deformation. These experiments settle the possibility of defending guns in casemates and turrets with a material much cheaper than forged iron or steel. The influence of mass is so great in constructions to resist large shot that a future seems opened for the use of chilled armor for land defenses. And to it I commend the attention of cast-iron gun foundrymen, whose plant the steel guns have rendered useless. Sixty-eight thousand tons of casting will keep them busy and leave the gun forges a fraction of work also."

Mr. Morgan's entire paper and the discussions that follow, by Lieutenant-Commander Barber, U. S. N., Captain Rogers Birnie, Jr., U. S. A., Mr. Oberlin Smith, and Lieutenant Beehler, U. S. N., form a valuable addition to the literature of military and naval science, and we recommend their careful perusal, not only by the mechanical engineers of the country, for whom the paper was specially written and discussed, but by all naval and military men interested in the subject of our coast defense.

C. R. M.

SPECIAL INTELLIGENCE REPORT ON THE PROGRESS OF THE WORK ON THE PANAMA CANAL DURING THE YEAR 1885.

By Lieutenant W. W. KIMBALL, U. S. N., assisted by Naval Cadet W. L. CAPPS, U. S. N.

After giving in detail the work done on the different sections of the canal during the year, the writer concludes with some general remarks, from which we quote:

"This report and previous ones show that a considerable plant is on hand, but it impressed me as being neither large enough as regards grand material, nor of the right kind. The machine shops appeared to be of sufficient capacity for the needs of the enterprise, conveniently arranged and economically constructed. The American dredges are excellent for the work expected of them, yet too few in number, since they could be used in many places where they are not applied. The Scotch dredges, too, are good machines, and the steam clapets all that could be expected, but, like the American dredges, too few in number. In the matter of excavators it would seem that the French chain-of-buckets machines are too light, great complaint being made of them for that reason. The Company is now receiving and setting up much heavier ones, weighing 60 tons each. When working in soft earth, free from stones and roots, there is no doubt that the chain-of-buckets machines have a greater capacity than those of the steam-shovel, American type; but these perfect conditions are often not to be had, and, consequently, some of the contractors prefer the American machines, although their possible capacity is less. The chain of buckets will be stopped by a small stone caught by the lip of a bucket, while the American steam-shovel will work uninterruptedly in stony ground and roots. The Company has withdrawn most of the American machines and substituted French ones. Apart from the fact that the American Osgood and McMaughten & Otis machines can work in more difficult soil than can the French excavators, some contractors prefer them because they do not require a line of rails the length of the cut to be in place before they can begin work, as they, placed on a short section of railroad, can use their shovels the full length of the handle without moving; in other words, they can cut 30 feet ahead, and the same distance to the side, straight into a bank, while the bucket machines must move to and fro along the cut they are making on a road laid beforehand—a three-rail road for the Everads, which dig below the level on which they stand. It is not always convenient to lay the double line of rails necessary for the spoils trains and the excavator, when one of these lines can be avoided by using an American machine. The 5-foot gauge of the Panama Railroad has been adopted for all the dump-lines along the canal, the rails being 30 kilograms, with a very high web. As it is necessary to use the Panama Railroad for transportation, it is of course convenient to run cars from either terminus of the road to any point on the company's switches or dump-lines, but it seems to me it would have been much more economical to have adopted a narrow gauge and to have laid a third rail over the Panama Railroad bed for transportation purposes. The advantage of a narrow gauge on the dumps, where sharp curves and stiff grades must be encountered, is apparent. This was illustrated on many curves, where the high-web rails had to be braced up by iron clips on every sleeper to counteract the tendency to capsize. The dump-cars in use are of the ordinary type and sufficiently good for the purpose; but the Belgian, box six wheel, and the Rogers drivers and bogey locomotives do not seem so well fitted for work in the dump as good saddle-back machines, since these first mentioned require such easy curves in order to haul economically.

The steam cranes for lifting rock seem to work well, but they are not used so extensively as one would expect. Great quantities of small material, mostly Decauville cars and rails, are in use even when it would seem that large material could be applied, and I was told that much Decauville work was being done, because the contractors could not procure large material by requisition on the company. In many cases I think the small material was used because the contractors did not care to pay the prices for the skilled labor necessary for the work with the large. For clearing the ground and doing preliminary work Decauvilles are admirable, but I was astonished to see them so extensively used for removing the spoils on work that had been in hand two years, as is shown in some of the photographs accompanying this report. The only explanation I could find was that the hand drilling and small blasting so

generally applied in rock work would naturally be attended by small material and hand work.

But few steam drills are used, the holes being pierced in most cases, even in long faces, by long hand drills used without sledges. Of course for such work the headings are low.

I have never comprehended why an outer harbor and inner basin should be dredged at enormous expense, when for one-quarter the cost a breakwater could be built from the lighthouse reef, and if necessary, another from Point Toro, which would make a perfect harbor of all Limon Bay. Wharfage on the terre-plein quay cannot be cited as a reason, since but little wharfage will be needed after the canal is open, and that little can be much more conveniently and economically supplied by piers like those at present in use at Aspinwall; and assuredly such wharfage would answer all purposes for landing construction material. Three or four long piers like those in use by the steamer companies would have been of the greatest value to the canal company in saving demurrage on vessels consigned to it while the terre-plein was being built, where even now the wharf room is insignificant. If the proposed stone quay were built, it would not answer the purpose required as well as piers. Limon Bay properly breakwatered would be a much more commodious and every way more convenient harbor than the dredged basin can ever be. The need of the Corozal basin is apparent. The section of the deflection of the upper Chagres near Gatun is 35 m. x 5 m., and the fall is only 1 m. in 7 k., giving a flow of between 1 m. and 2 m. per second. Now, as this section with the greatest flow passes only 350 mc. per second, and as the barrage tunnel will discharge 400 mc. per second, to which must be added the discharges of the Frijoles and Gatuncillo rivers, and a certain quantity for watershed, it would seem as if the section of the deflection would have to be increased. This is a mere detail, however, and there may be an intention to increase the section in accordance with needs developed. The only other point in the plan that seems to me impracticable is the placing of the canal, the deflection of the Rio Grande and the Panama Railroad, in the narrow valley between Culebra and the Cerro Coyo, where the substratum of slipping clay is found, and where the river must be so near to and so much above the canal, with the railroad so close to the river. I cannot understand what will prevent the deflection and railroad from sliding into the canal when it is dug, and it would seem that these would have to be carried through the hills to the right, if the river cannot be turned into the canal. The large basins between Corozal and Panama are only indicated, and are not really contemplated as a part of the plan.

The methods of work have been indicated more or less in detail in the reports of sections, but from a broader point of view, in regarding the work as a whole, a few other points demand consideration.

The general method, with some notable exceptions, as for example the dredging in the low ground at Colon and Gatun, has been to reduce the higher levels in the canal, dumping the spoils where most convenient, but oftener into the bed of the Chagres, and leaving the barrage and deflections of the upper Chagres for the future. The dumps have been placed 50 m. outside the canal banks, but in many places the slopes of the hillsides are such that there must be a considerable wash-down into the canal. Where the dumps are in the river, the current, of course, takes down a considerable quantity of spoils, which is to some degree deposited in the dredged portion of the canal, and which will have to be dredged out again. This operation will have to go on till the river is controlled and turned out of its course, and to me it seems singular that more work has not been concentrated on the deflection of the upper Chagres, so as to turn the river from its course as soon as possible. The deflection being cut, the dumps from the works in the canal could be utilized for building the numerous embankments in the bed of the river, none of which have been begun, and all of which, as regards the upper Chagres, must be in place before the river is controlled. This much accomplished, the river bed not needed

for deflection section could be used for dumping into without the possibility of there being any trouble from deposit in the canal. The longer this question is left unsettled, the greater will be the damage done by floods. It is true, the damage by the high water last December was only some tens of thousands of dollars, but it is an indication of what may occur in the future, and still the Chagres deflections are hardly begun. On the Panama side of the divide, where dredged work has nothing to fear from wash-down, and where the opened canal would be most useful for removing spoils, no dredging has been done.

The lack of power drills, the seemingly too extensive use of small material, the want of good switching and double lines for spoils trains, and the ineffective excavators have all been mentioned in this report; all of which would seem to indicate that the work is being done in a slower and more expensive way than is necessary. The only explanation I have heard is that, for financial reasons, it was considered best to show as soon as possible a good cubic extract from the basin of the canal, and that consequently the work was pushed with such material as could be easily secured, much of it small, and some of it, especially excavators, of a kind designed for Suez but not at all suitable for Panama.

I was much surprised that there is no intention of using hydraulic mining as practiced in the United States, especially as it could be so cheaply applied. At Culebra, for example, a small dam on the Rio Grande Superieur would hold sufficient water for a 2-inch pipe for four or five months in the year. The head would be between 30 and 40 metres, and the fluming required to bring the water to the working site not more than 600 or 800 m. long; the slope for washing down to the Paraiso plain is 1.5 to 1, certainly enough to move the spoils. Considering the work that could be done by that size of pipe and head of water together applied by a choke-bored monitor, it would certainly seem as if the mass at Culebra could be easily taken down to the Paraiso plain, and then dredged and dumped much more cheaply than it can be removed by the present method of small excavators and small spoils trains. In fact, I was informed that an offer had been made to wash Culebra down to the 10 m. level on the Panama side of the divide for 30 cents per mc.; and that another had been made to wash down the whole section, where washable, and take out all the rock, disposing of the wash spoils by mud-pumping it over the hill, and of the rock by dumping it well clear of the banks; to furnish all installation and plant, and to finish the work in two years at $2 per mc. for the job, giving $300,000 bonds to insure performance. The reason given me by my informant for the declination of the proposal was that no American contracts were wanted, and besides that hydraulics were not approved by the Ponts et Chaussées. To me it is patent that the Company had a better reason of some sort. It may have suffered at the hands of American contractors, but I cannot imagine that it would not use the methods that would be to its best advantage, or that the high talent of the Ponts et Chaussées would not grasp the utility of hydraulics. Still the fact remains that there is no preparation for using them, which is all the more curious when one remembers that the Gamboa barrage would give power for work all along the line with very little fluming, compared with the amount used in the United States for much smaller operations. One hears on the Isthmus a considerable amount of complaint in regard to national jealousy; that neither American contracts, American machines, American methods, nor American workmen are wanted; that French mechanics accuse American ones of trying to break down the excavators in order to stop the work, so that the Americans can get control of the canal; and much other such wild statement, which would appear to be the expression in words of the discomfort arising from mental depression due to the Isthmus malaria.

THE CHAGRES PROBLEM.

The plan for the barrage already given seems to me quite sufficient. Indeed, I do not understand the necessity for excavating for a foundation, since I can-

not conceive that the river could greatly displace a mass of rock dumped on the soil and in the bed. The slope at Gamboa is not sufficient to greatly aid the sliding of the rock, if it were dumped and the current allowed to cut the soil from underneath it, and consequently the rock would only sink until it found a solid foundation. Even if in building the rock were somewhat displaced, it would be only a question of dumping more. When built, no pressure of the water could push *down* a mass ten times as wide as it was high, nor can I conceive of its pushing such a mass *along*. Mr. Menocal, in his report, speaks of the grave engineering difficulties in building this barrage, but I understand that he was then speaking of the first project for a masonry dam. The enormous amount of work necessary for the construction of a barrage at least 40 m. high, 400 m. wide, and more than a mile long, is apparent, but the engineering difficulties are to me not at all patent. That the basin will be ample for holding the floods till the water can be drawn off through the tunnel, there seems to be no doubt. In fact, as regards the barrage and basin, the margins of safety are fully large enough, from my point of view. It should be borne in mind, in this connection, that the great rises in the Chagres do not mean an immense discharge. The floods at Matachin are of short duration, showing that they result from large local rainfall, but not from extensive water-shed. The accompanying tracing of the section of the river at Matachin at the time of the great flood, on the 25th November last, illustrates the rapidity of rise and fall—of the comparatively small amount of discharge there would be in ten days, although very great for one or two. The rise and fall of the river at Gamboa depends very little upon the rainfall there, not even when the fall for a month is considered; for example, last year the greatest monthly rainfall was in September, and was in the 19 rainy days of the month 408.9 mm., the average height of the river being 16.28 m., and the highest water 18.33 m. In the 19 rainy days in November the fall was only 336 30 mm., and the lowest water was 15.70 m., while the highest was 23.72 m. The rise was very rapid at the time of the flood.

At 7 A. M., 25th November, the river stood at 15 7 m.
At 7 P. M., 25th November, the river stood at 19.73 m.
At 7 A. M., 26th November, the river stood at 21.14 m.
At 7 P. M., 26th November, the river stood at 23.72 m.
The next day it was down to about the average level of the month.

Dead low water at Gatun in the dry season is 14.85 m. I have been particular in speaking of the flood because it is the highest there has been for seven years, and, therefore, a good example of what may be expected and of what the basin may have to hold. It is evident that the basin would easily have controlled the water coming down in that flood. With the barrage built, the deflections cut, and the embankments in place, the Chagres problem can, I think, be solved. Winslow speaks of the necessity of solid embankments at points where the canal crosses the Chagres at San Pablo, because at times the river rises 30 feet at Barbacoas. It is true that the river does so rise, but if the basin at Gamboa holds the surplus water and sends down only 400 m. c. s. through the deflections, the duty of the embankments will be to resist, not the torrent rising 30 feet in a night, but the stream corresponding to not more than 400 m. c. s., no matter what may be the conditions of floods above the dam. The embankments must be solid enough to resist the tunnel outflow, but they need be only high enough to bring the wide bed cut off to the section of the deflection. On the whole it seems to me that the Company has found the solution of the Chagres problem in theory, but the work necessary to put it in practice should have been some of the very first undertaken, when, as a matter of fact, it is hardly begun. Nearly all of the deflections are to be cut, and all of the embankments and barrage built.

No conclusions as regards time can be arrived at by manipulating the figures of extracted and remaining cubes. The Company has doubtless made some grave mistakes, but I am confident it has at its disposition all the necessary

brains and energy. As for human life, that is always cheap. The question of finishing the canal is then almost entirely one of finance.

From all the preceding it will appear that I have arrived at no conclusion as to whether or not the present company will finish the canal or when it will be finished, if at all; but from inspection, investigation, and observation I have become strongly impressed with the idea that if M. de Lesseps succeeds in placing the new lottery loan of 600,000,000 francs, if the money so obtained is expended with the economy that has lately shown itself in the Company's affairs, and if the work is energetically pushed by the best methods, the canal will be so far advanced by the time the money of the new loan is expended that the necessity for finishing it will be apparent." W. F. W.

BOAT-DETACHING DEVICE.

Invented by L. J. M. BOYD, Annapolis, Md.

The object of the device is to make it possible to detach a boat with promptness and certainty in any condition of weather. A hook is provided in each end of the boat, and is so swung that it will detach itself from the ring in the lower block of the boat-fall whenever it is set free by the movement of a detent. The detents (G) are operated by a single lever (H) through rods. After the lever is moved the falls cannot be hooked on until the lever is restored to its original position. The hooks are allowed to swing so far that they will detach, no matter at what angle the falls may lead away from them. The weight of the hook causes it, when set free, always to return to the position for hooking on, but to make this more certain a strong spring is also provided. In case it should be desired to overhaul the apparatus while the boat is at the davits, a pin is fitted to lock the hook and allow all other parts to be removed at leisure. The hole through the hook for the pin is enlarged so that there is no strain on the pin (I), when the detaching lever is in place. The length of the rods attached to the lever can be adjusted to allow either end of the boat to be detached a little sooner than the other. By putting in one of the locking pins, either end of the boat can be detached and leave the other hooked on securely. The rods are covered in the bottom of the boat, and the lever placed forward of and a little below the level of one of the thwarts, to be accessible and not in the way. For a four thousand pound boat a pull of only eighteen pounds on the lever is required to detach it. All parts of the device except the rods are cast, and are so made as to require very little finishing by hand or machine after leaving the foundry. They are made of malleable iron, phosphor or manganese bronze. The following is the report made by the Board appointed to test the device:

[Copy.]

U. S. NAVAL ACADEMY,
ANNAPOLIS, MD., *October* 19, 1887.

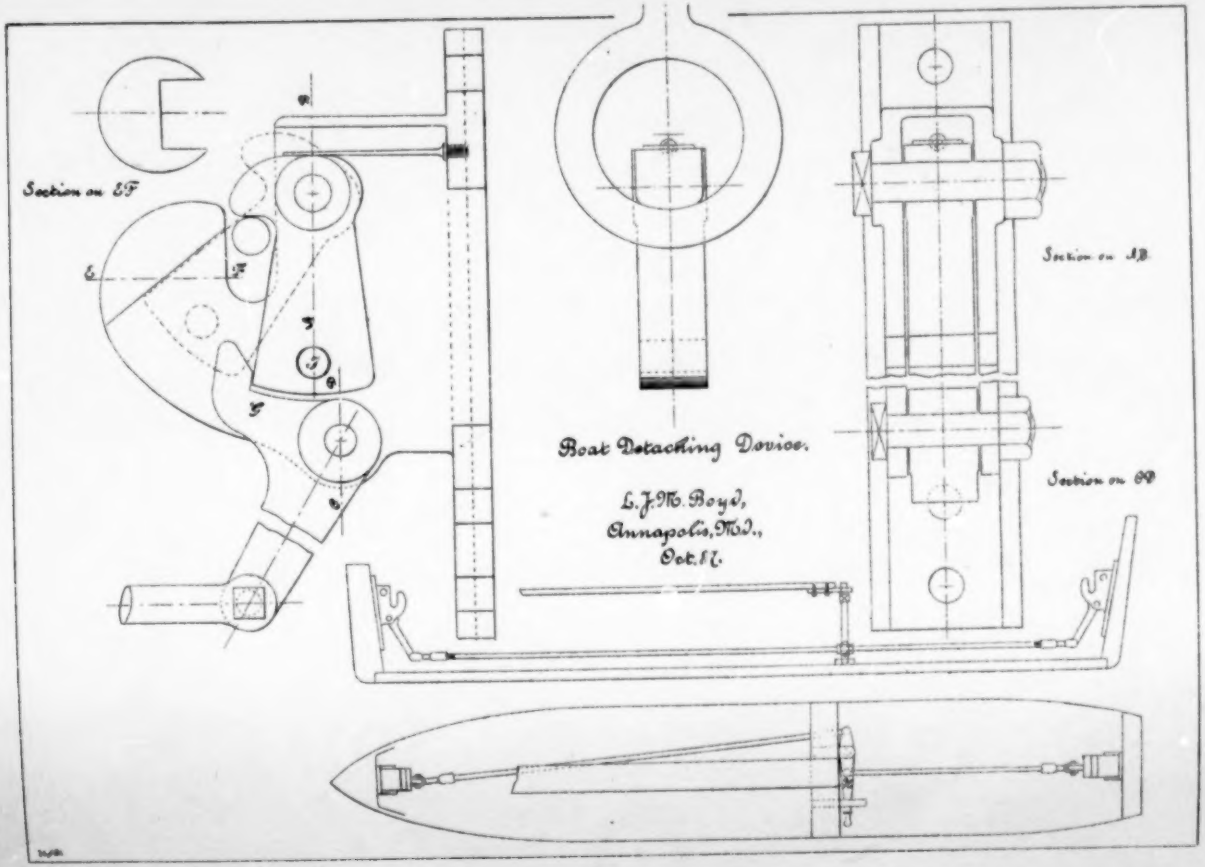
Commander W. T. SAMPSON, U. S. Navy, *Superintendent*.

Sir:—In obedience to your order of October 19th, we have examined the boat-detaching apparatus proposed by Mr. L. J. M. Boyd, as fully as possible in smooth water.

The apparatus was fitted to one of the cutters of the U. S. S. Wyoming, now alongside of the wharf. The boat was placed in as many different positions as possible and then detached. The apparatus worked satisfactorily, and we can say that, as far as we can judge from the above trials, it is the best apparatus we have seen.

We enclose drawings of the apparatus. The cost to put it on a boat would be about $20.* The ring necessary for the lower block can be hooked into any block.

*This amount does not include the cost of the labor necessary for attaching it to the boat.
L. J. M. B.


Section on EF
Section on AB
Section on CD
Boat Detaching Device.
L. F. M. Boyd,
Annapolis, Md.,
Oct. 11.

The apparatus is simple and takes but little room. The following are some of its principal advantages: The boat is easily hooked on at any time and the falls cannot unhook again. There is very little weight on the detaching lever, and therefore no liability to jam. The one lever detaches both ends of the boat. The connection between this lever and the apparatus in the ends of the boat is made of rods, so that there is no liability of fouling. The falls cannot unhook themselves in case any part of the boat becomes water borne. Should the boat be in the water before the lever is thrown back, the slightest strain on the falls will unhook them when it is thrown back. Safety pins are also provided with which to secure the hooks if it is thought desirable. They are arranged so that there is no strain on them as long as the lever is secured, they can therefore be pulled out easily. By leaving either of the pins in, the other end of the boat alone can be detached.

We would recommend the apparatus to be tried in some sea-going vessel, in competition with the best apparatus used in the service.

Very respectfully,

(Signed) C. T. HUTCHINS, Lieut.-Commander, U. S. N.
E. H. C. LEUTZE, Lieutenant, U. S. N.
C. E. COLAHAN, Lieutenant, U. S. N.

REPORT OF THE HOISTING OF THE ONE HUNDRED-TON DERRICK, MARE ISLAND NAVY YARD, CAL.

By Civil Engineer C. C. WOLCOTT, U. S. N.

NOTE.—The construction of a derrick or shears with capacity for lifting one hundred tons was authorized by Congress, March 3, 1885, the sum of $40,000 being appropriated for that purpose, and the 4th of August, 1886, an additional sum of $22,000 was appropriated.

On account of the excessive amount of the bids offered in answer to the advertisements for proposals, the plans were changed from the form of a crane to that of shears, and the work was authorized to be performed by the Steam Engineering Department of the Mare Island Navy Yard, under the direction of Chief Engineer George F. Kutz, U. S. N., in accordance with estimates submitted by him. The shears was successfully constructed by Chief Engineer Kutz at a cost of $37,152.07. The foundation and the erection, which is described in the following report, under the superintendence of Civil Engineer Wolcott, U. S. N., cost $7,223.18; making the entire cost of the shears in place, and including all labor and material, $44,375.25.

It is gratifying to note the success with which the navy yard force has completed this undertaking at a less expenditure than it would be possible to have the work done by private parties. It is one of several instances that has occurred at the same navy yard, wherein the navy yard workshops, notwithstanding the eight hours' system, has successfully competed with private establishments, both in regard to workmanship and cost. It is an evidence of what can be done at navy yards if the establishments are properly managed.

The Bureau of Yards and Docks took pleasure in acknowledging the success and ability of the officials concerned in this work, and the chief of the bureau in a formal manner tendered his thanks to them for the efficient manner in which the work was performed. C. H. S.

DEPARTMENT OF YARDS AND DOCKS.
CIVIL ENGINEER'S OFFICE, U. S. NAVY YARD,
MARE ISLAND, CAL., *June* 20, 1887.

Sir:—I have the honor to submit the following report of the operations attending the hoisting of the 100-ton derrick, and the subsequent trial when completed, ready for use.

The foundations for this important machine were completed in June, 1886, and a description of it was submitted in the annual report of that year; but for the purpose of having a complete description of the whole structure, it is inserted here.

By direction of the Bureau, the foundation was commenced on June 3d, 1886. Borings on the selected site developed hard pan and sand rock at a depth of 27 feet about the site of the back leg, and from 27 to 31 at the positions of the two front legs; these depths being below the low tide mark, it was necessary to drive piles to the hard bottom, to be sawn off at extreme low tide, as each of these legs has a load of 34,900 pounds. An area 10 × 12 feet was piled with large sticks spaced 30 inches apart, and driven to ultimate resistance; on these were placed 12 × 12 timbers and bolted to the piles; across these was laid a solid layer of the same sized timber, also bolted firmly to those below. This system of capping firmly bound the piles together. On this framework strong concrete, rammed with great vigor, was built up with battering sides to the proper level to support the cast-iron shoes of these legs. The transmitted load is in compression on these piers.

The maximum load being in tension (to a change to one of small compression in its back position), the foundation did not require such heavy piling; the piles here were driven 6 feet apart in a longitudinal direction, and 3 feet in a transverse, and forced well down into the hard pan. The excavation for this foundation was carried down to a line of low tide, at which point the piles were cut off and capped across the shorter axis with 12 × 12 timber drift bolted to the piles; across these caps was laid other timber of the same size (laid in contact), also bolted. At the outer end, where the maximum load in tension will be exerted, 12 large straps made of 2-inch iron forming a hook in its upper end and with a flat lower one, were bolted to the timber below the caps, which timbers were in turn through-bolted to the rows of piles; all these latter bolts were $1\frac{1}{16}$ inch. The hooks in the upper ends extend through the floor timbers, and through these hooks railroad iron was run.

The holding-down bolts of the track along which the crosshead of the back leg traverses are of 2-inch iron, with an eye turned in the lower end and a deep screw thread cut in the upper one. These bolts were 11 feet long, and the eyes were threaded on to the railroad bars, which in turn were placed under the hook bolts before described. These long bolts were spaced along the longer axis in proportion to the load to be borne, and varied from 7½ inches at the outer end to 4 feet 9 inches at the rear end.

Templates were placed over these bolts to hold them upright, and after a thorough coating with paraffine paint, the concrete base was laid on the floor timbers over the railroad iron and around these long bolts; thus all was built in together with great solidity.

As these bolts are all in the same vertical plane and extend through the concrete, any expansion in them would tend to split the concrete.

To obviate this and to bond all together, transverse bolts with 12-inch square washers were laid at varying distances in both a vertical and horizontal direction, and these, too, concreted in. This made a mass 56 feet long and 10 feet wide, bonded and tied together in a most thorough manner.

All the wood work is below the permanent water and will never decay. The iron work is thoroughly protected and will not rust.

The earth back filling about these foundations was thoroughly puddled and punned. When the castings for the foot plates and trunnions for the front legs and the rails for the crosshead for the back leg had been completed, they were most securely placed in position on these foundations.

When the work of constructing the various parts was completed, the legs were separately transported from the steam engineering shops to the site and laid upon the ground. The lower ends of the two front legs were placed between the trunnions of the foot plates, and the pin about which they are to move inserted. This brought the upper ends in proper position, and the back

leg was laid out in prolongation of the other two, and with its head between the others it was pinned there; the heads of the three were then raised by hydraulic jacks to allow the upper blocks to be hung. The derrick was thus spread out, and the distance from the lower pin hole in the front legs to that in the back leg was 246 feet.

The weight to be raised in the first moments of the lift was 54 tons, and the lower end of the back leg had to move 163 feet before it could be secured to the crosshead.

To raise these legs it was necessary to raise temporary shears, and which must be so placed that the legs would pass over them and yet not be in the way of the back leg when it came in position. The three longest and largest spars were borrowed from the Department of Construction and Repair; they were 81 feet long and 40 inches in diameter at the butt. In order that no delay should occur when once the operation of raising commenced, to change the purchase or remove other shears, only one set of shears was used, and these three spars were raised and lashed together with the feet of two of them inside of the main legs and 24 feet distant from the pins in the lower ends. This was as near as they could be placed to the head of the derrick, on account of the small distance they could spread. A large three-sheave block was secured as high on these shears as possible, and was 72 feet from the ground.

A toggle of large beams was made fast to the lower legs, 11 feet from the upper end, and to this were lashed the other blocks; the drift between the blocks was 100 feet. This position of the blocks, which was the best under the conditions, gave with the weight to be raised a strain of 54 tons at the first lift, and when the two blocks came opposite each other the head of the derrick would be only 72 feet above the ground, and from this point it would be forced into place by hauling on the foot of the back leg.

The U. S. S. Hartford was made fast to the sea wall to serve as a holdfast for the guys for the temporary shears, and to allow of the use of her steam capstan for the hauling power on the main purchase. Six guys were led aboard and made fast to toggles laid across the beams of the berth deck, and a leading block laid in the gangway made a fair lead to the capstan.

As the back leg had to move forward as the head was raised, a boat of heavy timber was placed under the heel and resting on a bar, which in turn was secured to the leg so that it might turn as the head was raised. This boat rested on box rollers laid on a track of beams, which extended to the point where the crosshead was to be met, and which was run back on the turning screw to its furthest limit.

On either side of the back leg near this boat, heavy tackle was made fast, the other being secured to chain cables passed around the foot plates of the front legs; the hauling part of the side tackle was brought to a windlass on either side; these were worked by horse power.

The resultant of the weight of the front legs and the reaction of the power necessary to raise this passed outside the centre base of the front legs, and there was danger of overturning these pair as well as the sea wall. To prevent this, large anchor chains were placed around these foot plates and the rear end of the track of the back leg.

Commencing at 7.20 A. M. the derrick was raised to the highest point possible by the main purchase, and then the side tackles were brought into operation and the back leg run into place and secured to the crosshead. There was no accident or hitch of any kind, and all worked very smoothly.

Great credit is due to the men engaged in this, and especially in the service and skill of Bart Willman, a first class rigger, worthy of commendation, for he was entrusted with the placing of the rigging, and that no accident occurred in its progress is largely due to his attention.

The next day the wooden shears were lowered by means of the new derrick. After their removal, the hoisting engine, drums, and boiler were put in place on foundations already prepared for them, steam was gotten up, and the various parts tried, though no weight was used.

Everything worked in a perfect manner. The hoisting gearing is easy to control, and the traversing of the back leg is smooth and uniform in its movements.

The derrick can now be regarded as complete and ready for service, and will fully meet all the requirements. The limit of the load to be placed on this machine can with safety largely exceed 100 tons.

The workmanship on the metal part of the derrick is of the highest order.

The Foundation.

Cost complete, ...	$4,976 17

Erection.

Cost complete, ...	1,493 13
Filling in around foundation, restoring roadway, hauling, plans, &c.	758 88
Total, ...	$7,228 18

Appended is a tracing of the foundations as they exist.

Very respectfully,

C. C. WOLCOTT, *Civil Engineer, U. S. N.*

Captain BYRON WILSON,
In charge of Department of Yards and Docks,
Navy Yard, Mare Island, Cal.

Respectfully forwarded,

BYRON WILSON, *Captain, U. S. N.*

COMMANDANT'S OFFICE,
NAVY YARD, MARE ISLAND, CAL., *June* 21, 1887.

Forwarded for the information of the Bureau.

GEORGE E. BELKNAP, *Commandant.*

THE NAVAL COMBATS IN THE WAR OF THE PACIFIC, 1879–1881.

By LUIS URIBE Y ORREGO, Captain, Chilian Navy.

(An Abridged Translation by Prof. JULES LEROUX.)

In this volume, the naval engagements in the Pacific between Chili and Peru are for the first time considered under their technical aspects, in a full and interesting analysis, the object of which is to set forth the instructive lessons taught by each of them. Leaving aside the causes of the war, the author lays great stress on the facts, until lately disputed, but now generally admitted, that Chili was totally unprepared for the contest, and that the situation of her Navy in particular was critical, but still, on the whole, that the forces that were about to dispute the supremacy of the sea were not far from equal.

On the 12th of April, 1879, Captain Latorre, of the Chilian gunboat Magallánes, on a mission north, sighted to the northeast, and bearing down upon him, the Peruvian corvettes Union and Pilcomayo, and though he could easily have avoided an encounter, he determined to fight his way through. After a short running fight the Union suddenly bore up and gave up the chase. This action on the part of the Peruvian corvette has been variously commented upon. According to Commander Latorre, the Union was forced to abandon the chase owing to serious damages to her machinery from the effects of two 115-pounder shots from the Magallánes. The escape of a great quantity of steam from the funnel of the corvette coinciding with these shots gives at least great sem-

blance of probability to his statement. On the other hand, it is denied by some that the Union was at all injured by the firing from the gunboat, and they explain the unusual movement of the corvette by the bursting of her boiler tubes, owing to a too heavy pressure of steam, in her efforts to come up with the Chilian vessel. It must be remembered, however, that the Union possessed superior speed, and was at least a half knot faster than the Magallánes, from which she stood only at 2300 metres, that is, within fighting distance. It is also singular that the commander of the Union makes no mention whatever of this accident to the boilers of his vessel, in his official report.

Though lacking in interest as a subject for study, this action nevertheless points out the necessity that vessels which, owing to their relative inferiority, may be forced to refuse the combat, shall so arrange their guns that the heaviest piece may be trained to fire astern. If the Magallánes had been able to point her 115-pounder pivot gun right aft, it is doubtful whether the Union would have followed in her wake; and, *vice versâ*, if on this occasion the corvette had been armed with efficient bow chasers, it would not have taken her long to put her antagonist *hors de combat*. In support of this it is only necessary to cite the deadly fire that the Cochrane maintained on the Huascar in the engagement off Punta Angámos, when the latter vessel made the fatal mistake of turning and running before the Chilian ironclad within gunshot. Nobody ignores the importance of parallel firing, especially since the introduction of armor and the ram in naval warfare.

The general use on board of men-of-war of the automobile Whitehead torpedo, with its perfected method of handling, is another factor in attack and defense which will render hazardous hereafter the pursuit of vessels provided with this class of weapons. The hesitation of Captain Grau of the Huascar in attacking the Esmeralda at close quarters, during the engagement at Iquique, while he was in doubt as to the presence of torpedoes on board the Chilian, lends support to this idea, and its truth is further demonstrated by the ludicrous incident that took place later on, between the same Huascar and the Matías Cousiño. The Matías Cousiño was a Chilian transport loaded with coal intended to be transhipped at sea to the other vessels of the squadron during the expedition against Callao. The transhipment was to be made by means of two barges hung on each side of the transport. Somehow the Matías Cousiño got separated from the rest of the squadron the first night out, and she remained cruising off the coast for nearly two weeks. One evening her captain sighted a steamer to the southward. Not doubting for one moment that it was one of the vessels of the squadron in search of him, he steered straight towards it. But, to his astonishment, the stranger bore away and headed west. Still unsuspicious, he followed the fugitive. Just as the sun went down, the fog, which had been very thick, cleared a little, and to his horror, the captain of the Matías found himself close in the wake of the dreaded Huascar. Captain Grau had also recognized the adversary before whom he was fleeing, and the face of affairs suddenly changed. Terror lent wings to the transport, she turned and fled, with the monitor in hot pursuit. In order to lighten his vessel, and also to oblige his pursuer to alter his course, Captain Castleton cut loose his two barges one after the other. This stratagem had an unhoped-for result. Captain Grau, who had already been deceived by these barges, whose position on board the Matías gave the latter the appearance of an ironclad with its citadels, which explains his previous flight, seeing them coming towards his vessel, in the dark mistook them for torpedoes, and night-fall adding to the probability of meeting the Chilian ironclads off Iquique, he gave up the chase and headed north. We have related the above incident somewhat at length in order to show to what use a vessel closely pursued or threatened with ramming could put her torpedoes.

When, on the 17th of May, 1879, the main portion of the Chilian squadron sailed north on their expedition against Callao, two small wooden vessels, the corvette Esmeralda and gunboat Covadonga, were left in charge

of the blockade of Iquique. This was a good opportunity for the Peruvian ironclads Huascar and Independencia, which had obtained knowledge of the movements of the enemy's squadron. On the 21st they suddenly appeared off Iquique, and at once began the attack; the Huascar choosing the corvette, and the Independencia, the gunboat. The Huascar was the first to open fire on her antagonist, and for two hours a lively cannonading was kept up on both sides; yet, so great was the want of training among the Peruvian crew, that during all this time they succeeded in planting only one 300-pound shot in the sides of the corvette, whose feeble artillery failed in turn to make the least impression on the armor of the monitor. Captain Grau then determined to try his ram in order to bring matters to a conclusion. Twice he struck the corvette; the first time with no apparent result, but the second, with palpable effect. The boilers of the Esmeralda were in the worst possible condition, and with her reduced speed she was unable to avoid the full force of the shock of the ram. The monitor struck her on the port bow at an angle of 45°, leaving a gaping aperture through which the water rushed into the engine room, extinguishing the fires and flooding the powder magazine. The corvette was now perfectly helpless—she lay motionless on the water; but, as she would not surrender, Grau had no alternative but to ram a third time, striking her full on the starboard side. The corvette went down almost immediately, with her colors flying at the peak.

Meanwhile the Covadonga, exposed to the furious attacks of the Independencia, made all efforts to escape. Hugging the rocky coast as close as the shallow water would permit, she lured her adversary after her over the shoals of Punta Gruesa. The inexperience of the gunners of the Independencia was here made as manifest as that of the Huascar's, and, in spite of his overwhelming superiority, Captain Moore despaired of putting an end to this protracted combat. He, too, decided to resort to his ram. After one or two futile attempts he finally saw his opportunity. Unluckily, at the most critical moment the men at the wheel were shot down, and the vessel falling off, was fast aground in an instant. The Covadonga stopped one moment to take the offensive, but the appearance of the Huascar on the scene obliged her to resume her flight south, and though leaking badly, and carrying only five pounds of steam, she escaped, no doubt owing her safety to the time lost by the monitor in communicating with the Independencia when she hove to abreast of her wrecked consort. Grau in his official report makes no mention of his stopping, but on the contrary leaves it plainly to be understood that he pursued the Covadonga for three consecutive hours. It is hard to reconcile the two versions. Indeed, the fact that Punta Gruesa is situated 11 miles south of Iquique, and that at this date the Huascar's speed was 10½ knots an hour, whilst that of the Covadonga did not exceed five, makes it evident, admitting the correctness of Grau's statement, that at the end of a 3-hours' chase the monitor would have stood 19 miles south of Punta Gruesa, *i. e.* 3 miles further south than the gunboat, which could not have covered more than 15 miles in the same interval.

In corroboration of the above we will relate the following: The surviving officers of the Esmeralda, who had been placed under guard in the ward room of the Huascar, remembered distinctly that the monitor, which had been running at full speed, stopped suddenly and lowered one or more boats (this they could tell by the peculiar grating and creaking of tackles during such operation), and started again immediately afterwards. Later on one of the Peruvian officers came down in the room, and entering into conversation with the first prisoner he met, inquired casually about the speed of the gunboat. His interlocutor chanced to be the assistant surgeon of the Esmeralda, who had only a month before set his foot on board a man-of-war for the first time. The young doctor, little versed in such matters, answered carelessly that the speed of the Covadonga was 10 miles an hour. The Peruvian did not wait for more, he hurried up on deck, and shortly after a peculiar motion of the ship

announced to us that she had altered her course and probably headed north. Evidently her commander, misled by the intelligence just received, had given up all hope of catching the gunboat and abandoned the chase.

The above little incident shows also the advisability of keeping at all times, but especially in times of war, the general public in ignorance of the speed of the vessels of a squadron. Had Grau remained even the least doubtful about the rate of the Covadonga, it is not likely that he would have so easily relinquished the pursuit of the latter.

Speaking of the rate of a ship, we are put in mind of that frequent and always perplexing question, "How fast is your vessel?" In order that a steamer may develop at all times its maximum speed, a combination of various elements is requisite, such as a well trained and sufficiently numerous *personnel* in the engine room, coal of good quality, and a clean bottom. The war of the Pacific furnishes many examples showing that the quality of coal is of as vital importance as any other fighting element of a ship; and one would not be far wrong in venturing the opinion that the capture of the Huascar by the Chilian ironclads was in a great measure due to the inferior quality of her coal as well as to her foul bottom.

The action of Iquique does not present sufficient data from which to determine conclusively the value of attacks with the ram; the contestants were too unequal in size, build, and armament. It must be remembered, too, that the Esmeralda, owing to the bad condition of her boilers, was almost motionless. Yet, in spite of that, she only succumbed to a third attack of the ram of the Huascar. If we compare these attacks with the fruitless efforts of the same Huascar in assailing the Magallánes, a few weeks later, in the same waters and under almost identical circumstances, when the monitor did not even succeed in scratching the paint on the sides of the corvette, we may be excused for feeling less sanguine as to the efficiency of that weapon, than those who are of opinion that the ram is destined to play a most important and decisive part in modern naval warfare. After all, what has been said and written on the subject up to this day are isolated opinions and mere conjectures based mostly on theoretical calculations, which, on being put to the proof and transferred to the field of action, which is the sea, either fail entirely or fall short of the expected results. And it cannot be otherwise; the same thing happens with experiments in the perforation of armor plates. It is not a rare thing to hear, or even read in scientific reviews and periodicals, that since guns can be made to pierce the heaviest armor that can float, there is no excuse for the existence of armor-clad ships. Those who reason thus do not seem to take into account that the *penetration tables* are based upon experiments made on land under circumstances most favorable to the gun and most unfavorable to the plates.

The loss of the Independencia was a terrible blow to the power of Peru; yet, while the Huascar was free to commit hostilities along the Chilian coast and baffled all efforts to capture her, Chili could not undertake any serious land operations. Orders were therefore given by the Government to capture or destroy the Peruvian monitor at all hazards. Without loss of time, the commanders of the squadron determined upon the following plan of operation. Having noticed that the Huascar whenever she was pursued always changed her course to westward and then headed northward, it was agreed that the slowest vessels of the squadron, the Blanco Encalada and Covadonga, should sail south along the coast at a distance of from five to six miles, whilst the Cochrane, O'Higgins, and the Loa should cruise at sea, keeping well off the land, say about 20 miles from the nearest cape.

Early one morning, the 8th of October, 1879, the Blanco Encalada sighted two steamers coming from the direction of the land and apparently bent on reconnoitering. The division at once bore down upon them, when they altered their course and sailed in an opposite direction. This circumstance looked suspicious, and the thought of the Huascar flitted through the mind of the Chilian commander. He was right. Daylight revealed the Peruvian monitor

and her consort, the Union, fleeing at full speed before him. He then signalled the vessels of his divison to slow up, so as not to force those of the enemy too far west. These, feeling safe from pursuit, altered their course as had been anticipated, and headed north under easy steam. One hour thus passed in chase, the Blanco Encalada meanwhile forcing her fires as much as the bad condition of her boilers would permit, and anxiously scanning the horizon for the division that was to intercept the fugitives. Finally, the lookouts at the masthead descried columns of smoke in the northwest, and shortly after it became evident that the other division was manœuvring to head off the Peruvian ships. Grau, seeing himself caught in the trap so skillfully laid for him, and the impossibility of avoiding an engagement, signalled his consort to part company and make all efforts to escape north. This the Union found no difficulty in doing, thanks to her well known speed.

The combat of Punta Angámos, thus named from the headland off which it took place, has been described and commented upon with more or less accuracy by the El Mercurio, which had a correspondent at the seat of war, and by foreign naval officers, among them Lieutenant Mason, U. S. N., and also by Mr. Clement R. Markham, in his work entitled "War between Peru and Chili"; it is therefore useless to describe it here. We cannot help remarking, however, that the comments of some of the writers and the conclusions reached in regard to the movements and manœuvring of the Huascar in that engagement are erroneous.

Let us first consider the chances of escape of the Peruvian monitor, or if that was impossible, then the means for the offensive she had at her disposal. In our opinion, at the moment she sighted the Cochrane, several courses lay open before her:

1. She could put about and fight her way south against the Blanco if she found it impossible to avoid an encounter.

2. She might try to escape to the northeast between the Cochrane and the land, trusting to her heels as she had so often done before successfully.

3. She could steer southwest without fear of being molested by the Blanco, drawing after her the Cochrane, whose speed did not exceed hers by more than half a knot, and over which she had a lead of at least 12 miles.

As is known, Grau chose the second course. Had he chosen the first instead, *i. e.* had he veered around and attempted to escape south, he would not perhaps have found it very hard to avoid the Blanco, whose speed did not exceed 9 knots; but if debarred in that direction, then the southwest lay open before him. Finally, having adopted neither of the last two plans, and finding an action with the Cochrane inevitable, his best chances were to bear straight down upon the latter and attack her resolutely, thus equalizing the offensive powers of the two vessels. But the Peruvian admiral allowed the Cochrane to take up her position on his stern, and thus resigned himself without a protest, so to speak, to his fate. Some will claim, perhaps, and, among others, Lieutenant Mason in his pamphlet, "The War on the Pacific," that the Huascar made attempts at ramming the Cochrane. Let us examine the facts. Before Grau was killed, that is, during the first half hour of the engagement, it is well known that all the energy of the Huascar was concentrated in her efforts to escape to the northeast, and if, while heading in that direction, she once sheered a little to port, she did it in order to bring the guns in her turret to bear, and not, as asserted by some, in order to ram the Cochrane. After the death of Admiral Grau and the disabling of her steering apparatus and speaking tubes, the Huascar became practically unmanageable, that is, as far as precision of movements and attacks with the ram were concerned. Finally, some at least of these pretended attacks, admitting there were any, were not such in reality, but only the consequences of the bad steering of the monitor, which, on falling off to starboard (which she did repeatedly, owing to a deflection of her ram), made her present her prow now to the Cochrane, then to the Blanco, and even to the Matías Cousiño; a fact which explains partially the statement of

Captain García y García, of the Union, who represents his unfortunate consort as fighting right and left against the whole Chilian squadron. Experience has shown that it was impossible for the Huascar to maintain her course at full speed with her temporary steering gear. It then remains demonstrated: 1. That while it was in the power of the Huascar to use her ram with more or less success, *i. e.* during the first half hour of the engagement, she did not do so. 2. That later on the only time she attempted to use it, she was prevented from carrying out her intention by her bad steering.

One of the many lessons taught by the action of Angámos is the advisability of providing for the ship's commander one or two secondary protected stations supplied with speaking tubes connecting with the engine room, the wheel house, and the battery respectively.

When we consider that it is from the captain's station that proceed all the orders which give life and motion to that costly and complicated engine of war called a modern ironclad, and further that upon the physical and moral ability of the occupant of the turret will depend, in the majority of cases, victory or the most terrible disaster, we cannot surround him with too much protection. As will be remembered, the pilot house of the Huascar was destroyed almost at the beginning of the action, and with it the speaking tubes, rendering communication with the engine room and the wheel very difficult.

Some of the remarkable features of this memorable fight, aside from the foregoing considerations, is the frequency with which the Huascar was hit, nearly one-third of the shots telling, and the repeated disabling of her steering gear; the first being due, no doubt, to the strategical position of the Cochrane on her quarter, and the second, to the exposure of her steering apparatus above the water line.

One word in regard to the demoralization and confusion created among the crew by the terrible effects of the bursting of the Palliser shells in the interior of the monitor, which were the immediate cause of her surrender, since it may be said that her vital parts were intact. It has often been said by the friends of unarmored vessels that it matters little for the final result whether the portion of the hull above the water line were honeycombed (such is their expression) with shot, as long as the vital parts and the engine remained intact. It is evident that those who reason thus have not taken into account the demoralizing effect produced among the crew of a vessel by the bursting of the shells in its interior, especially when engaged against an adversary whose guns are protected by armor.

The last act of the drama was played. The capture of the gunboat Pilcomayo, November 18, 1879, and the engagement of the Chilian fleet against the forts of Arica, present no features of salient interest.

FRENCH PROTECTED CRUISERS.

(From *Le Yacht*, September 24, 1887.)

The Minister of Marine has advertised for plans for barbette cruisers of the first and second class. For the cruisers of the first class, the hulls are to be entirely of steel, and are to be protected at the water line by a belt of armor 10 cm. in thickness. The conning position and guns are to be protected by shields of the same thickness. A steel deck is to extend fore and aft and a coffer-dam around the ship. The division of the ship into water-tight compartments is to be as complete as possible. They are to have two military masts and are to carry two 47-mm. guns in each top. Each is to have four torpedo tubes. The armament is to be: two 10-cm. and six 16-cm. guns, on hydraulic carriages, distributed in such a way that five pieces can fire at the same time either ahead, astern, or abeam. In addition, they are to have two

65-mm. and four 47-mm. rapid-fire guns; eight 37-mm. revolving cannon. The speed is to be, with forced draft 20 knots, with ordinary draft 17.5 knots. They must be able to run four thousand miles at 12.5 knots. The crews are to consist of four hundred men. Each cruiser is to be lighted with electricity throughout.

The cruisers of the second class are to have the same general arrangements. The armor is to be 8 cm. instead of 10 cm. The armament is to be: two 16-cm. and six 14-cm. guns; two 65-mm. and four 47-mm. rapid-fire guns, and eight revolving cannon. They are to have three armed tops, the fore carrying two 47-mm. guns, the others one each of 37-mm. Each is to have four torpedo tubes. This class are to have four steel masts, rigged square on the fore and fore and aft on the others. The speed is to be the same as those of first class. The crews are to consist of 300 men. Each is to be lighted by electricity.

D. H. M.

BOOK NOTICES.

THE HOTCHKISS SYSTEM OF RAPID-FIRING GUNS. Printed for private circulation. London and Paris, 1887.

Containing descriptions and illustrations of the 37, 47 (light and heavy), 57, and 65-mm. guns, and 10-cm. gun, with their ammunition, mounts and carriages for the naval and military services, together with firing tables and penetration diagrams, as determined by official tests on the firing grounds of Europe and the United States.

This book is written in a clear style and much detail is observed. It shows a decided advance of the rapid-firing system by its application to larger guns. Some space is devoted to the quality of the steel employed in the manufacture of Hotchkiss guns, and also to the strength of the guns. A chapter is devoted to the efficiency of the rapid-firing gun in defense from torpedo-boat assaults. In this the author advocates with reason the use of the tangent bar-sight in preference to the ladder sight, and from a consideration of the trajectory, ranges at which the gun will be used, and the chances of hitting, arrives at the conclusion that the best range at which to set the sight bar permanently, it being impracticable to change it during a torpedo-boat attack, is 800 yards for an arc covered by only one gun. Where two guns cover the same arc, one should be set permanently at 750 yards and the other at 900 yards, to ensure the greatest number of hits. The author names 600 yards as the range for which the sliding leaf should be compensated to allow for wind and speed, and lays great stress upon firing only with a direct aim at the object.

In addition to what is contained in previous issues on the same subject are descriptions of shrapnel for the rapid-fire guns with the Elswick combination time and percussion fuze, together with the Hotchkiss and Desmarest pose fuzes for shell.

A drill cartridge is devised in which service rifle ammunition may be used. This cartridge admits of reloading, and only necessitates marking the rear sight for this ammunition. The larger calibres 65 mm. and 10 cm. are also new. A general description of the rapid-firing gun applicable to all calibres is given, but no detailed description of individual guns or nomenclature of parts, as in previous issues. The gun drill is also omitted. In addition to the military mounts are described the non-recoil or crinoline mount, the Elswick and Hotchkiss recoil mounts, and a pivot carriage for the heavier guns. The directions for mounting and dismounting are very clear and complete. The illustrations are in thirty-four plates from photographs.

The book as a whole is very interesting and instructive, and is obviously well worth perusal by naval and military officers. J. H. G.

FROM Carl Gerold's Son in Vienna we have received Pola, Its Past, Present and Future. This brochure contains a very readable history of the city from its foundation by the Romans in 178 B. C. to the present time. The whole is accompanied by cuts and maps. The book is of interest from the fact that Pola is now the seat of the principal dockyard and naval arsenal of Austria.

J. F. S.

CONTRIBUTIONS TO THE LIBRARY.

We wish to acknowledge the receipt of the following books for the Library of the Institute :

Los Combates Navales en la Guerra del Pacifico, 1879–1881. Por Luis Uribe y Orrego, Capitan de Navio de la Armada de Chile. Presented by the Author.

War of the Rebellion. Official Record of the Union and Confederate Armies. Vols. VI–XIX. Presented by Prof. M. Oliver, U. S. N.

Survey of the Northern Boundary of the United States from the Lake of the Woods to the Summit of the Rocky Mountains, with Atlas. Presented by Prof. M. Oliver, U. S. N.

A Treatise on Artillery. By H. Lallemand, General of the Artillery of the late Imperial Guard of France. 1820. Vols. I. and II. Presented by Prof. M. Oliver, U. S. N.

The Practise of Artillerie. By Robert Norton, One of His Majestie's Gunners and Engineers. A very curious and entertaining old work on ordnance, printed in London in 1628. Presented by Alfred H. Cowles, Lockport, N. Y.

BIBLIOGRAPHIC NOTES.

ANNALEN DER HYDROGRAPHIE UND MARITIMEN METEOROLOGIE.

15TH ANNUAL SERIES, 1887, No. 4. Observations for the magnetism of the earth by the International Polar Expeditions. Report of a reconnaissance on the east coast of Africa, made by H. I. M. gunboat Hyäne. The rivers Malimba and Benudo, west coast of Africa. Deep-sea soundings in the Arabian Gulf, U. S. S. Essex. Currents in the Indian Ocean, observed by H. I. M. ships Sophie, Carola, and Bismarck. Report on the voyage of the German brig Nicolaus from Liverpool to Banana, thence via West Indies to Kopenhagen. Remarks about Tamarindo and Corinto, on the Pacific coast of Central America. Voyage of the Danish cruiser Fylla to Baffins Bay, 1886. Geographical positions of different parts of the world. Two hurricanes in the northwestern part of the Pacific Ocean off Japan. Weather chart of the North Atlantic Ocean. Short Notices: Regulations for the navigation of the Suez Canal by night. Tides in Finsch Harbor. Kaiser Wilhelm's Land. Remarks about several islands of the Ellice group, Gilbert group, Union group, and Phoenix group. Entrance to Palaevan, Island of Mindora Fusan, east coast of Corea. Inland passage between Amoy and the river Min. Vladivostock. Karsakowsk, south end of the island of Saghalien. Kaan Island, South Pacific Ocean. Bottle-post.

No. 5. Samana Bay, San Domingo. Description of the coast of Kaiser Wilhelm's Land. Nimrod Sound, China. Distribution of the temperature of the water at the surface of the ocean. Determination of the position and characteristics of islands and reefs in the ocean. Cyclones in the Gulf of Bengal. Hurricanes and gales in the South Pacific Ocean in the vicinity of Easter Island. Rain of ashes in New Guinea. Short Notices: Mouth of the river Congo. West coast of Africa, near Cape Negro and Cape Albino. Wood's Hull, east coast of the United States. Mayaguez, Porto Rico. Ras al Khyle, east coast of Africa. Currents and surface temperatures in Formosa Straits. Harbor of Hiute, Gulf of Anend, Chiloe, east coast of Chile. Remarks about several islands of the Panmotu archipelago. Bottle-post.

No. 6. The influence of the rotation of the sun on the magnetism of the earth. Sailing directions and descriptions on the east coast of Africa. Remarks about the Solomon Islands. Christmas Island in

the Indian Ocean. Navigation about Cape Gordafin during the S.W. monsoon. Frequency of storms near the times of equinox. March typhoons in Japan. Upper air currents near the equator. Short Notices: Sailing directions for leaving St. Paul de Luando. Soundings on the bar of Maracaibo. Currents on the east coast of Africa between Zanzibar and Capetown. Port Phaeton, Tahiti. Bottle-post.

No. 7. Quarterly review of the weather observations of the German Nautical Observatory, Fall of 1883. Hydrographic observations of H. I. M. S. Adler in Bismarck archipelago, Kaiser Wilhelm's Land, and the Anachoreten and Hermit Islands. Deep-sea soundings in the North Atlantic Ocean, U. S. S. Juniata. Deep-sea soundings in the Indian Ocean, U. S. S. Essex. Currents, ice, and navigation near the Coast Islands. Rains on the Island of Mauritius and adjacent parts of the ocean. Short Notices: Temperature and currents in the Corral Sea. Bottle-post.

No. 8. The use of oil to calm the sea: examples. Extracts from the log of the German bark Speculant, west coast of Central America. Deep-sea soundings in the Indian Ocean, H. M. S. Flying Fish. Quarterly review of weather observations of German Nautical Observatory, Fall of 1883: conclusion. Rain chart of the Atlantic and Indian Oceans. Chart of the division of the Indian Ocean into stations for the vessels observing for the German Nautical Observatory. Short Notices: Mossamedes, west coast of Africa. Bottle-post.

E. H. C. L.

BULLETIN OF THE AMERICAN IRON AND STEEL ASSOCIATION.

No. 22, JUNE 29, 1887.

The steel stern-post for the cruiser Charleston was successfully cast on the 22d inst. by the Pacific Rolling Mill Co., at San Francisco. The post is 22 feet long on the keel, with an upright of 20 feet, and weighs about 15,000 pounds.

The Standard Steel Works at Thurlow, Pa., cast a steel stern-post for gunboat No. 1, weighing 15,000 pounds, and an engine bed-plate for the cruiser Baltimore.

W. F. W.

No. 24, JULY 13. Southern resources for the manufacture of iron and steel.

A paper by the editor, James M. Swank, giving a resumé of the progress of the Southern States in the manufacture of iron and steel since the war, and of the resources of Maryland, West Virginia, Tennessee, Alabama, North Carolina, and Georgia in the production of iron ore.

No. 25, JULY 20. Big guns gone off at Boston.

A description of the two immense 90-foot gun lathes and accompanying crane to be removed from the South Boston Iron Works to the Watervliet Arsenal.

Production of pig iron and steel in the first half of 1887.

No. 26, JULY 27. Three valuable statistical iron and steel tables.

No. 27, AUGUST 3 and 10. The iron industry of the Basque Provinces. Relation of the iron industry of the South to that of the country at large.

No. 28, AUGUST 17. Prices of iron and steel from 1885 to 1887.

Giving a table of the monthly range of prices for the eight leading products from January, 1885 to August, 1887, averaged from weekly quotations.

No. 29, AUGUST 24. Important financial operations in the new Northwestern iron ore fields.

A description of the large companies formed for the purpose of mining the new Northwestern ore fields.

No. 30, AUGUST 31. The Bethlehem gun and armor contracts.

An explanation of the report that foreign aid has been sought by the Bethlehem Iron Co. in its fulfillment of the contract to furnish guns and armor for the Government.

No. 31, SEPTEMBER 7. Sketch of the late Alfred Krupp.

A translation by Joseph Wharton of an obituary article in the August number of the *Stahl und Eisen*.

No. 33, SEPTEMBER 21. Iron and steel imports for July and August.

A summary in tabular form of the imports of iron and steel into the United States from all countries.

No. 35, OCTOBER 5. An electrical street car.

An electrical motor applied to a street car has been successfully tested in Philadelphia. The storage batteries are placed under the seat in one corner of the car, and are said to be able to run the car for four hours. The power thus obtained is said to be cheaper than either horse or cable power.

No. 36, OCTOBER 12. Our iron and steel imports in August.

Tabulated from the monthly summary of the Bureau of Statistics, Treasury Department.

No. 38, OCTOBER 26. Importing a million tons of British iron and steel in nine months.

The import of steel rails amounted alone to 135,621 tons; of pig iron, 331,326 tons; of unwrought steel to 183,210 tons. The exports of iron and steel from Great Britain to all countries, from the first of the year to October 1, amounted to 3,104,131 tons. C. R. M.

COMPTE RENDU DES TRAVAUX DE LA SOCIÉTÉ DES INGÉNIEURS CIVILS.

JANUARY, 1887.

This number contains a very interesting paper, by M. Cabanallas, on the application of electricity to the transportation and distribution of energy; also, an exhaustive mathematical study of the efficiency of various forms of dynamos and the special advantages of each for different purposes. The conclusions to be drawn from this paper point to a steady advancement in the advantages to be gained by the employment of electricity as a mode of transmission of energy, and to an increase in the degree of excellence of machines for its production. As its advantages are made more apparent, the forms of

motors needed for reconversion of electrical energy into mechanical work will become more numerous, causing an increasing field for the inventor during the next few years, and stimulating to activity and perfection the companies now in the market.

JUNE, 1887.

Under the Notes in this number a new method for the production of sodium is described. It has been employed advantageously by a company formed in London, and promises to make it possible to separate this metal from its carbonates by a comparatively cheap process. The price will, it is said, become about 25 cents a pound. With the reduced price of sodium it will be possible to procure both aluminium and magnesium at very much lower rates, causing thereby a diminution in the cost of Mitis steel. S. M.

ENGINEER.

JUNE 3, 1887. The submarine torpedo boat Nordenfeldt.

Account of trial on 26th May of the fourth and largest submarine boat built by Nordenfeldt. She is 125 feet long, and when immersed displaces 245 tons. I. H. P. 1200.

JUNE 10. The Italian cruiser Dogali.

Length over all, 267 feet; length between perpendiculars, 250 feet; breadth moulded, 37 feet; depth moulded, 20 feet 6 inches; draught of water forward, 13 feet; draught of water aft, 16 feet; draught of water, mean, 14 feet 6 inches; displacement, 2050 tons; indicated horse power, natural draught, 5000; forced draught, 7700; speed, forced draught, 19.66 knots. Armament, six 6-inch breech-loading guns on centre pivot, Vavasseur mountings; nine 6-pounder rapid-fire guns on recoil carriages; six Gardner guns; one bow torpedo gun, fixed; one stern torpedo gun, training; two broadside training torpedo guns.

The vessel has twin screws, each propeller being driven by a triple expansion horizontal direct-acting engine. Storage is provided for 500 tons of coal, which would serve at maximum speed for a run of about sixty hours or 1100 knots, or at half speed for about twenty days or 4500 knots. The vessel is rigged with two military masts, with light fore and aft sails. The tops are arranged as revolving towers, completely hiding the gunners. Each top carries one Gatling gun. The whole length of the hold of the vessel from stem to stern is protected by a steel deck of a minimum thickness of 1 inch and a maximum of 2 inches. The vessel carries two search lights of 20,000 candle power, and a complete outfit of internal lighting. This vessel is the first war ship fitted with triple expansion engines. Diameter of cylinders 30, 45, and 73 inches; stroke, 2 feet 9 inches. Marshall's valve gear. Propeller three bladed. Independent pumps. Condensers of brass. There are four boilers, each with six furnaces. Blower, driven by Brotherhood engines. Engines in separate water-tight engine rooms, with doors moving horizontally, worked from deck. The boilers are in two water-tight stoke holes. On trial the engines worked well at 155 revolutions, 7600 I. H. P., and speed 19.66 knots.

JUNE 24. The Nordenfeldt submarine boat at Constantinople.

On the 7th June No. 2 boat was tried for five hours at Constantinople, steaming at surface and below, running for two hours of the time on steam stored in the reserve boiler and had 90 pounds pressure at conclusion, so that she could have gone on longer.

AUGUST 5. The engines of the Dogali (Italian cruiser). Illustrated.

AUGUST 12. H. M. S. Trafalgar (illustrated). Ludborg's Ship Section (illustrated).

AUGUST 19. The management of marine boilers: editorial.

In the English merchant marine great difficulty is found in preventing rapid corrosion of boilers. In the Navy this is obviated by using open tanks to collect the feed water and allow all air to escape. The feed pump is arranged to pump only "solid" water, and care is taken when suspending zinc plates in the boiler to secure perfect metallic connection.

An improved water gauge float.

AUGUST 26. The use of petroleum fuel. Marine engines from a shipowner's point of view. Petroleum refuse as a fuel: editorial. Cost of transmission of power by electricity, water pressure, compressed air, and ropes.

SEPTEMBER 2. Steel faced armor; trials in Russia (illustrated).

SEPTEMBER 9. Experiments on the mechanical equivalent of heat on a large scale.

The result showed that the mechanical equivalent of heat is 769 instead of 772, as found by Joule. The difference is ascribed to the fact that in the apparatus used all losses of heat were prevented, no losses had to be calculated, and the specific heat of the apparatus did not enter into calculation, as it was kept at a practically normal temperature throughout. W. F. W.

ENGINEERING.

JULY 1, 1887. The "Brennan" torpedo (concluded). Hydropneumatic disappearing gun carriages at the Newcastle Exhibition. Defects in the designs of war ships.

JULY 15.

H. M. S. Undaunted, a belted cruiser, recently had a four hours' forced draught trial loaded down to the water line. Draught forward 20 feet, aft 22 feet; total I. H. P. developed 8602. Speed on measured mile 19.4 knots, the highest yet attained by any English heavily armed ship of war.

The Board of Admiralty are of opinion that the dockyards should build the great bulk of the ships required for the Navy, and this year, out of thirteen ships required, eleven will be so built.

The Spanish torpedo boat Ariete, on trial, steamed a short time at the rate of 26 knots. A peculiar feature is the "pipe" boiler, a development of the Herreshoff boiler, and considered by the designer, Mr. Thornycroft, an improvement.

JULY 22. The Impérieuse.

The general conclusion derived from an experimental cruise was that the ship was a successful war ship, but would be improved by removing her masts entirely.

Dr. Gustaf de Laval's new submarine boat. Thornycroft's water-tube boiler (used on the Spanish boat Ariete).

JULY 29. Progress and development of the marine engine.

AUGUST 5. Progress and development of the marine engine.

Abstract from paper read before the Institution of Naval Architects.

AUGUST 12. Progress and development of the marine engine: discussion.

AUGUST 19. The engines of the Nicolas I. Illustrated.

Triple expansion engines arranged so that the L. P. cylinder is easily thrown out of use when working at reduced power.

AUGUST 26. Liquid fuel for locomotives: editorial.

SEPTEMBER 2.

A twin-screw steel torpedo gunboat named the Grasshopper, and of 450 tons displacement, has been launched. She will have engines of 3000 I. H. P., speed 19 knots, and carry one 4-inch steel B. L. and six 3-pounder rapid-fire guns, and three torpedo tubes.

SEPTEMBER 23.

From experiments made in Portsmouth Dockyard on the variation in the resistance of metals with an increase in temperature, it appears that the strength of iron increases uniformly up to 500° F., but the ductility diminishes up to about 300° F., after which it increases again till a somewhat higher temperature is reached, and thence remains nearly constant up to a temperature of 500° F. Steel tested in a similar way showed no deterioration in strength up to the highest temperature named, but at this point its ductility was diminished one half.

H. M. S. Trafalgar.

The Trafalgar was launched at Portsmouth, and is the last great armor-clad which it is proposed to build. She is the largest and most formidable battleship ever constructed in this country (England), and is larger than either the Admiral Baudin or the Formidable of France, although inferior in displacement to some of the armor-clads of Italy. She may be said to represent the most perfect protection by means of armor against the power of a gun at a time when it is seriously contemplated to abandon armor. The following are some particulars: Length, 345 feet; breadth, 73 feet; mean draught, 27 feet 6 inches; displacement, 12,000 tons; thickness of armor at water line, 14 inches and 20 inches (steel faced); thickness of armor on turrets, 18 inches (steel faced); height of armor above water, 11 feet; engine power, 10,500 I. H. P.; speed, 16.5 knots; bunker capacity, 900 tons; principal armament, four 67-ton B. L. R.; weight of projectile, 1250 pounds; weight of charge, 630 pounds; cost of hull and machinery, £800,000. Hydraulic power is used for working the large guns and many of the auxiliary engines. The ship can steam 5500 knots at 10 knots per hour, or 1050 knots at 16½ knots per hour.

Armored ships. Interesting letter from Sir E. J. Reed.

SEPTEMBER 30. Steam pipe explosion on board the S. S. Elbe.

W. F. W.

JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES.

JULY. The use of pairs of circumpolar stars for finding the true meridian.

An article describing a method available on land for finding the true meridian when the time is not accurately known.

Weights and measures.

A report of a committee of the Boston Society of Civil Engineers, with a discussion showing progress in the extension of the metric system, and pointing out means to secure its adoption in the United States. H. S. K.

JOURNAL DU MATELOT.

OCTOBER 15, 1887. Turn-abouts and vidette boats.

OCTOBER 22. Several experiences in using oil in storms: the passenger steamers Abd-el-Kader in the harbor of Sfax, and the Manoubia in the roads of Mostaganem. D. H. M.

JOURNAL OF THE FRANKLIN INSTITUTE.

VOLUME CXXIV., No. 739. The use of oil for stilling waves: with a description of a new oil distributor for the use of mariners.

This distributor, which is the invention of T. F. Townsend, Philadelphia, consists of a hollow metal globe, ten inches in diameter, with a capacity of one and a half gallons. It has an air chamber to float it in an upright position, and two valves to regulate the flow of the contents.

No. 740. A simplification of the new weather signal code. The reaction of a liquid jet.

No. 741. On anemometers.

No. 742. Improvement of tidal rivers. Was Philip Reis the inventor of the articulating telephone? Pyro-magnetic motors and generators of electricity.

At a recent meeting of the American Association for the Advancement of Science, Mr. Thomas A. Edison called the attention of the public to a very ingenious device, by means of which he has been able to convert the heat of coal or gas into electric currents by means of magnetism. The machine consists of a core of soft iron made of sheet metal, having a thickness of .002 of an inch, and rolled so as to permit hot gases to pass between the sheets. This core is surrounded by a coil of wire, and while the core is in a strong magnetic field it is alternately heated and cooled, thus inducing currents in the coil. It is found, however, that the rapid oxidation and disintegration of the thin metal presents a serious difficulty.

No. 743. Improvement of the port of Philadelphia. Description of an improved triple-expansion engine. J. H. G.

JOURNAL OF THE MILITARY SERVICE INSTITUTION.

JUNE, 1887.

Lieutenant E. L. Zalinski contributes a very interesting and instructive article on the pneumatic dynamite torpedo gun, under the following heads: (1) Evolution and development of the machine. (2) Accuracy of fire. (3) Use for coast defense. (4) Counter-mining. (5) Use against torpedo boats, dirigible torpedoes, and submarine boats. (6) Use as an adjunct when ships attempt ramming. (7) Torpedo rams. J. H. G.

JOURNAL OF THE ROYAL UNITED SERVICE INSTITUTION.

VOLUME XXXI., No. 140. Accuracy of artillery fire. Alterations lately made in H. M. S. Ajax, illustrating the truthfulness of the results obtained by experiments on her model in the tank at Torquay. Coaling ships of war at sea. The interior economy of a modern fleet.

THE RAILROAD AND ENGINEERING JOURNAL.

AUGUST, 1887. Quadruple-expansion marine engines. High pressure marine boilers. The new naval vessels. Hydro-pneumatic disappearing gun carriage.

Sir W. G. Armstrong, Mitchell & Co., Elswick, England, are the makers of a new disappearing gun carriage. The recoil is utilized for compressing air in a chamber of the recoil cylinder, by means of water or other fluid which is forced from the outer chamber through a valve into the air chamber. At the same time the movement of the piston in the cylinder is communicated, by means of a cross-head, to a pair of elevating levers, in the upper ends of which the gun trunnions are carried, the lower ends being connected to the gun carriage. After loading, the compressed air is utilized for raising the gun.

SEPTEMBER. The new war ships. The English naval review. Fighting ships. The new yacht Volunteer.

OCTOBER. The increase of the American navy. Engravings of the English ironclad Trafalgar, and of the English 67-ton gun.

NOVEMBER. Lieutenant Bradley A. Fiske, U. S. N., contributes a continued article, "How Electricity is Made." J. H. G.

MINUTES OF PROCEEDINGS OF THE INSTITUTION OF CIVIL ENGINEERS. VOL. XC., 1886-1887. PART IV.

Selected papers No. 218.

The Use of Cast Steel in Locomotive Engines, by John Alfred Hill, Wh. Sc. Stud. C. E., gives the details for which cast steel can be conveniently and economically applied in the construction of locomotives, together with tables (I.) showing how the strength of steel castings is affected by their chemical composition, (II.) the effect of annealing, and (III.) the result obtained from testing six specimens, two being cast steel, two forged steel, and two forged iron.

Selected paper No. 227.

Platt and Hayward, on Strength of Iron and Steel, give experiments on the strength of iron and steel in shear and torsion.

Foreign abstracts: A volumetric method of estimating the carbon in iron, by J. Wiborgh.

The novelty of this process consists in the direct measurement of the carbonic acid produced from the oxidation of the carbon in the sample under investigation, instead of weighing it as potassium carbonate, as is usually done.

Electric time signalling on the German coast, by Prof. Dr. W. Förster.

MITTHEILUNGEN AUS DEM GEBIETE DES SEEWESENS.

VOL. XV., Nos. VII. and VIII. Night attacks by torpedo boats, by Captain A. v. Becker. Use of hyperbolic functions in navigation, by Prof. E. Gelcich. Episodes from the history of maritime wars. Corrosion of iron and steel ships, and their protection against it (Institution of Naval Architects). French regulations for preserving auto-mobile torpedoes. Minor notes from foreign periodicals.

No. IX. Photographic determination of the disturbance of air produced by shot,* by Prof. P. Salcher. Parson turbo-electricity generator (from Engineering). Use of submarine boats in war. The latest mechanical methods for drawing stability curves of vessels. Notes from foreign magazines.

No. X. Progress in the development of the marine steam engine (from English articles). Experiments for finding the relative conductivity of boiler deposits, by M. Burstyn. The gunboat as a factor in coast defense, by Admiral Sir Geo. Elliot. Notes from foreign magazines. E. H. C. L.

PROCEEDINGS OF THE ROYAL ARTILLERY INSTITUTION.

MAY, 1887. Artillery fired from railway wagons.

Details of experiments with 40-pounder B. L. R. on railroad trucks or Indian metre-gauge road.

JUNE. Remarks on high-angle and direct fire from coast batteries, by Col. G. A. Crawford, late R. A.

"I think we may conclude that to fire high-angle shells at a modern ironclad will be a thorough waste of ammunition, as well as a waste of *personnel* in employing gunners to man them in our coast batteries. On the other hand, if ships of war attacking earth forts were armed with a complement of howitzers, their high-angle fire against elevated forts would be very annoying and disturbing both to the forts and to the gun detachments; in fact, it is the only sort of artillery fire that could touch the fort. Howitzers therefore might be suitable weapons for our ships."

Direct fire.

"The proper weapons for our modern coast batteries are: *guns, heavy, medium, quick-firing* and *machine guns*, and the projectiles to be fired from them are: *armor-piercing, shrapnel* and *case;* the proportion being—65 per cent armor-piercing, 20 per cent shrapnel, 15 per cent case. Since the introduction of our new B. L. guns, the range for piercing armor has increased to 4000 yards, and even longer when firing at thinly clad ships; and the scattered gun system, with guns mounted at elevations of two, three, four, or even five hundred feet above the sea, gives the fort numerous advantages both in attack and defense. The ship becomes much longer under fire. A concentrated fire can be brought to bear on it. A deck fire from elevated sites is obtained. And for defense, the greater the altitude of the fort the safer it is from a ship's fire.

"In harbor defense, we may safely conclude that an enemy's ship will not attempt to anchor, so that the target we shall have to fire at will always be a moving target. I have come to the conclusion that with well trained gunners it is as easy to hit a ship in motion as a ship at anchor."

Partial details of the experiments and practice at high-angle and direct firing, on which these conclusions are based, are given.

The French troops in Algeria, by Captain E. Lambart, R. A.

From this a few good hints in regard to the physical training of soldiers might be obtained. Of no interest to naval reader.

* This article being such a valuable addition to the literature of ordnance, a full translation of it will be published in the next number of our Proceedings.

A machine gun battery in Burma, by Captain W. N. Lloyd, R. A.

Gives an interesting description of the method of mounting and transporting the Gardner gun through the jungles of Burma.

JULY. Quick-firing guns.

Gives details of experiments and results obtained with guns of the Hotchkiss and Nordenfelt systems in England, France, and Italy.

AUGUST. Letters on artillery.

Gives summary of preceding letters. F. A. W.

SEPTEMBER. Journal des Sciences Militaires, translated by Captain W. P. Thring, R. A.

Treats of artillery before the battle: I. Marches in time of war; II. Instruction and training; and III. Artillery horses.

More notes on fire of artillery above infantry, by Captain E. J. Garnet, R. A. C. R. M.

REVUE D'ARTILLERIE.

OCTOBER, 1887. On the choice of the point blank. Rules for the manœuvres of the Austrian artillery. Experiments with small arms in Sweden from 1884 to 1886. The Maxim automatic mitrailleuse. Various items:—Germany—Bridge building by cavalry. England—Resumé of guns injured in practice; Military velocipedes. Russia—Formation of a battalion school for non-commissioned officers; The canal of Pérékop. Book notice: Further investigations regarding wire-gun construction, giving several problems from the work of I. A. Longridge. D. H. M.

REVUE DU CERCLE MILITAIRE.

JULY 10, 1887. Experiments with topedoes and torpedo boats at Portsmouth, England.

JULY 17. The action of infantry fire on field of battle. The German soldier judged by a Spanish diplomat.

JULY 24. Continuation of paper on infantry fire.

JULY 31. Continuation of same paper.

AUGUST 7. Conclusion of same paper. The Staff Academy of Russia.

AUGUST 21. New regulations for field service in the German army.

SEPTEMBER 4. Night operations (army).

SEPTEMBER 11. The defenses of Holland.

SEPTEMBER 25. The manœuvres of the German fleet in the bay of Eckernförde and at Wilhelmshaven. The new Chinese squadron.

OCTOBER 2. Attack on intrenchments, these being preceded by accessory defenses. The electric light in time of war (army). The Meteor, Austrian torpedo-boat destroyer (contre-torpilleur).

OCTOBER 9. Attack on intrenchments (end of article). Military chronicle:—Germany—Cruising corvette Ersatz Ariadne, and rapid-fire cannon. England—Launch of the Trafalgar. Mitrailleuse for the cavalry.

OCTOBER 16. In regard to fire with repeating arms. Torpedo boats of the Italian navy. Military chronicle:—Actual state of the question of torpedo boats in different countries. D. H. M.

REVUE MARITIME ET COLONIALE.

JULY, 1887. Austrian expedition to Jan-Mayen Island. The dromoscope. The use of oil at sea. The Legion of Honor. Navigation in times of fog. The Italian cruiser Dogali. Recent attacks, against the Resistance, with torpedoes. The submarine torpedo boat Nordenfelt. A new Chinese torpedo boat.

AUGUST. The gyroscope-collimator (continued from December, 1886). New system for the projection of the sphere; generalization of Mercator's projection. Voyage from Noumea to Brest. The employment of the syren, with a system of echoers. The cinémomètre or speed indicator. Chronicle—Naval review at Spithead; Raising the Resistance; "Bellite," a new explosive; Trial of a submarine torpedo boat at Constantinople; The most recent sea-going torpedo boat; The Ariete, Spanish torpedo boat; Instantaneous photographing for use on men-of-war; The routes by way of the Cape of Good Hope and by the Suez Canal compared.

SEPTEMBER. Study of combined operations of fleets and armies (continued from June, 1887). A voyage in Senegambia. Historical studies on the French navy. Chronicle—Simulated attacks against English ports; The naval review at Spithead; The Impérieuse and Warspite; The composite sloop Nymphe; New United States ships of war; A swift yacht; The Russian ironclad Alexander II.; The English torpedo boat No. 80; The Brennan torpedo.

OCTOBER. The naval apprentice battalion of L'Orient. History of the French navy. Combined operations of armies and fleets: Voyage in Senegambia. Two years in Tonquin. Chronicle—The English naval manœuvres as reported upon by the judges; Reforms in the English Admiralty; The Italian naval manœuvres; The Spanish torpedo boat Rayo. D. H. M.

TRANSACTIONS OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

VOLUME VIII., 1887. Formulæ and tables for calculating the effect of the reciprocating parts of high-speed engines, by Geo. I. Alden. Casting aluminum bronze and other strong metals, by Thos. D. West.

A valuable addendum to the remarks of this author on "Aluminum Bronze for Heavy Guns," published in the present number of our Proceedings.

Should a piston packing ring be of the same thickness at every point? by L. H. Rutherford and F. R. Hutton. Notes for discussion in relation to the development of the compound engine, and the probable limit of steam pressure in marine engines and boilers, by Chas. E. Emery. Notes for discussion on cylinder condensation, and the reduction of the same by the use of the compound engine, by Chas. E. Emery. What are the needs of our Navy? by Ramsay H. Ashton. Our coast defense, its cost, and its mechanical problems, by Joseph Morgan, Jr.

Reviewed at length in the Professional Notes of the present number of our Proceedings.

Steam and power; the commercial determination of its cost, by Henry R. Towne. C. R. M.

UNITED SERVICE GAZETTE.

JULY 2, 1887. An article on navy guns.

JULY 9. P. 547: Description of the Undaunted.

JULY 16. P. 566: Trial trip of the Undaunted.

JULY 23. Quick's breechloading ordnance.

AUGUST 6. Spanish torpedo boat Ariete; also Thornycroft's water tube boiler, giving plans of boat and boiler.

AUGUST 13. Admiral Sir George Elliot on English coast defenses.

AUGUST 27. Bland's patent diamond sight.

SEPTEMBER 3. The electric lighthouse on the Isle of May, drawings and description.

SEPTEMBER 17. Firing with the "fixed sight" (practical hints by a well known expert). Australian naval defense.

SEPTEMBER 24. Reorganization of English War Office. Electric lighting of barracks. Launch and description of Trafalgar.

OCTOBER 8. The rifles of modern armies.

OCTOBER 15. Trial of the new Spanish war ship Reina Regente on the Clyde. The Gioto, a new torpedo cruiser for the Italian navy. Steam trials of the English vessels Australia and Forth.

OCTOBER 22. Indirect musketry firing. The Meteor, the fastest torpedo cruiser afloat, constructed by Schichau at Elbing, for the Austrian navy; speed, 23.1 knots per hour. D. H. M.

LE YACHT.

JULY 9, 1887. P. 254: Triple expansion engines.

JULY 16. P. 259: Proof trial of an armor target, being a section of the armor intended for the Iver-Hvitfelt of the Danish navy.

P. 262: View of English torpedo boat Fearless. Accidents to the boilers of English torpedo boat No. 47.

JULY 23. P. 267: The defects of torpedo boats. P. 269: The manœuvres of the French squadron. The cruising torpedo boat Faucon. P. 271: An article on the English navy by E. Weyl. P. 272: Plans and description of Brennan's movable torpedo. P. 273: View of Italian cruiser Dogali.

JULY 30. P. 285: Plan and description of apparatus for throwing oil on water during a storm.

AUGUST 6. P. 298: The Spanish navy.

AUGUST 13. P. 306: The Spanish navy (continued).

AUGUST 20. P. 311: Modifications to the rules of the road—to prevent collisions. P. 316: An experiment on the application of electricity for moving steamers. Transportation of a torpedo boat by rail—views of boat and carriages.

AUGUST 27. P. 323: The Spanish navy (concluded).

SEPTEMBER 10. P. 340: Plan and description of the Trafalgar. P. 342: View and description of German gunboat Eber.

SEPTEMBER 17. P. 349: Plans of Spanish torpedo boat Ariete (to go with article in Le Yacht of August 13, 1887). P. 348: Two letters on means of preventing collisions in fog.

SEPTEMBER 24. P. 355: The subject of collisions considered by E. Weyl. P. 357: Projects for protected cruisers of the 1st and 2d class in France.

OCTOBER 1. P. 365: Navigating in time of fog.

OCTOBER 15. P. 383: The personnel of the French reserve. P. 389: Picture of the English cruiser Mersey.

OCTOBER 22. P. 396: The currents among the Channel Islands (French). D. H. M.

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A prize of one hundred dollars and a gold medal is offered by the Naval Institute for the best Essay presented, subject to the following rules:

1. Competition for the Prize is open to all members, Regular, Life, Honorary, and Associate, and to all persons entitled to become members, provided such membership be completed before the submission of the Essay. Members whose dues are two years in arrears are not eligible to compete for the Prize until their dues are paid.

2. Each competitor must send his essay in a sealed envelope to the Secretary and Treasurer on or before January 1, 1888. The name of the writer shall not be given in this envelope, but instead thereof a motto. Accompanying the essay a separate sealed envelope will be sent to the Secretary and Treasurer, with the motto on the outside and writer's name and motto inside. This envelope is not to be opened until after the decision of the Judges.

3. The Judges shall be three gentlemen of eminent professional attainments (to be selected by the Board of Control), who will be requested to designate the essay worthy of the Prize, and, also, those deserving honorable mention, in the order of their merit.

4. The successful essay shall be published in the Proceedings of the Institute; and the essays of other competitors, receiving honorable mention, may be published also, at the discretion of the Board of Control; and no change shall be made in the text of any competitive essay, published in the Proceedings of the Institute, after it leaves the hands of the Judges.

5. Any essay not having received honorable mention, may be published also, at the discretion of the Board of Control, but only with the consent of the author.

6. The subject for the Prize Essay is, *Torpedoes.*

I. *Their place in naval warfare.*

II. *Character of the torpedoes and torpedo vessels required for the naval service of the United States.*

III. *Organization of our naval torpedo service and instruction of its personnel.*

IV. *Tactics to be employed in offensive and in defensive warfare.*

7. The essay is limited to fifty printed pages of the Proceedings of the Institute.

8. The successful competitor will be made a Life Member of the Institute.

9. In the event of the Prize being awarded to the winner of a previous year, a gold clasp, suitably engraved, will be given in lieu of a gold medal.

By direction of Board of Control.

CHARLES R. MILES,
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ANNAPOLIS, MD., *January* 1, 1887.

APPENDIX.

VOL. XIII., 1887.

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BY B. F. TILLEY AND C. R. MILES,

Editing Com., U. S. Naval Institute.

PRESS OF ISAAC FRIEDENWALD,
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UNITED STATES NAVAL INSTITUTE.

1873-1887.

ORIGIN, PROGRESS, AND OBJECT.

Historical.

The inaugural meeting of the Institute was held October 9, 1873, at which Rear-Admiral John L. Worden, U. S. N., presided, and the late Commodore Foxhall A. Parker, U. S. N., read a paper entitled "The Battle of Lepanto." The object of the association as then stated was for the advancement of professional and scientific knowledge in the Navy by affording a medium for the free interchange of serious thought and the debate of important subjects concerning naval science and practice. In 1874 a Constitution was adopted and the membership increased to seventy-five. The first volume, entitled "The Papers and Proceedings of the United States Naval Institute," appeared in 1875. During the succeeding few years the Institute grew in membership and in the estimation of the Army and Navy, and by the adoption of the Constitution of June 2, 1884, it took a firmer hold and marked out its future success. At present its membership is as follows—viz. Honorary members, 7; life members, 75; regular members, 575; associate members, 130.

In addition to its membership the Institute has a large number of subscribers and exchanges, so that now the published quarterly edition numbers 1350 copies.

Since its organization the field of usefulness of the association has become enlarged, and besides the first object, already mentioned, its work includes the following:

1st. By means of the large number of associate members, comprising Army officers, those of the Revenue Marine, naval architects of distinction, consulting and mechanical engineers of high standing, and the leading manufacturers of steel and other material for the Navy, it promotes good feeling and mental stimulation, which are broadening and beneficial to all parties.

2d. Its members and subscribers, including libraries and colleges, disseminate important authentic information relating to naval science and to the subject of national defense.

3d. The Professional and Bibliographic Notes furnish a compendium of valuable information, taken from home and foreign sources, to which most members have not access.

4th. The publications of the Institute become a repository for important historical records concerning the naval service, as well as for valuable reports of experiments in a form convenient for reference.

Publications.

"Quarterly, or as much oftener as the Board of Control may decide," the Proceedings are published, and one copy is mailed to every member. Up to the present time forty (40) numbers have been issued, the contents of which may be seen in Table of Contents as published in this catalogue. Full sets may be obtained from the Institute by application to the Secretary and Treasurer.

General Information.

Membership.—Under the Constitution (Article VII.) the active members of the Institute are divided into three classes, styled respectively: Regular, Life, and Associate Members. The provisions for Honorary Membership are embodied in Section 4, Article VII.

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For information on any subject of business with the Institute, address the Secretary and Treasurer, U. S. Naval Institute, Annapolis, Md.

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Remittances should be made payable to the order of the Secretary and Treasurer, U. S. Naval Institute.

Additions to the Library.

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Fitts, J. H., Virginia Agr. and Mech. College, Blacksburg, Va.
Fletcher, F. F. Lieutenant
Fletcher, W. B. Ensign
Flynne, L. Lieutenant
Folger, W. M. Commander
Ford, J. D. P.-Asst. Engineer
Ford, W. G., Jr. New York
Forney, James, Major, U. S. M. C.
Forsyth, Jas. M. Lieut.-Commander
Fox, C. E. Lieutenant
Franklin, S. R. Rear-Admiral
Freeman, E. R. P.-Asst. Engineer
Fullam, W. F. Lieutenant
Galloway, C. D. Lieutenant
Galt, R. W. P.-Asst. Engineer
Garrett, L. M. Ensign
Garvin, J. Lieutenant
Gatewood, R. Asst. Naval Const'r
Gause, J. T. Wilmington, Del.
Gearing, H. C. Lieutenant
Gheen, E. H. Lieutenant
Gibbons, J. H. Ensign
Gibson, W. C. Lieut.-Commander
Gillis, H. A. Susquehanna, Pa.
Gillmore, J. C. Lieutenant
Gilman, A. H. Pay Director
Gilman, H. K. 1st Lieut. U. S. M. C.
Gilmore, F. P. Lieutenant
Gilpatrick, W. W. Lieutenant
Glass, Henry, Commander
Gleaves, A. Ensign
Glennon, J. H. Ensign
Goodrich, C. F. Commander
In charge U. S. Torpedo Corps
Gorgas, A. C. Medical Director
Gorgas, M. C. Ensign
Graham, J. D. Commander
Graham, S. L. Lieutenant
Grant, A. W. Ensign
Greene, B. F. Professor
Greene, F. E. Lieutenant
Greene, S. Dana, Ensign
Greer, J. A. Commodore
Griffin, T. D. Lieutenant
Grimes, J. M. Lieutenant (retired)
Gross, C. J. Baltimore
Gunnell, F. M. Surgeon-General
Haeseler, F. J. Ensign
Halford, Wm. Gunner
Hall, A. L. Ensign
Hall, M. E. Lieutenant
Hall, Reynold T. Asst. Engineer
Halsey, W. F. Lieutenant
Hannum, W. G. Lieutenant
Hanscom, J. F. Asst. Naval Const'r
Harber, G. B. Lieutenant
Harkness, W. Professor
Harlow, C. H. Ensign
Harmony, D. B. Commodore
Harrington, P. F. Commander
Harris, U. R. Lieutenant
Hasson, W. F. C. Asst. Engineer
Hawley, J. M. Lieutenant
Hayden, E. E. Ensign (retired)
Hazlett, I. Lieut.-Commander (ret.)
Heald, E. De F. Lieutenant
Hemphill, J. N. Lieut.-Commander
Henderson, A. Chief Engineer Naval Advisory Board
Herbert, W. C. Asst. Engineer
Herwig, H. P.-Asst. Engineer
Hetherington, J. H. Ensign
Hichborn, P. Naval Constructor
Higgins, R. B. Cadet Engineer
Higginson, F. J. Commander
Hoff, W. B. Commander
Hollis, Ira N. Asst. Engineer
Holman, Geo. F. W. Lieutenant
Hosley, H. H. Lieutenant
Houston, E. S. Lieut.-Commander
Howard, W. L. Ensign

Howison, H. L. Captain
Howland, C. H. Providence, R. I.
Hubbard, J. Lieutenant
Hubbard, N. M. Cedar Rapids, Ia.
Hughes, W. S. Lieutenant
Hunicke, F. H. St. Louis, Mo.
Huntington, C. L. Commander
Huntington, R. W. Capt. U. S. M. C.
Huse, H. McL. P. Ensign
Hutchins, C. T. Lieutenant
Hutchins, Hamilton, Lieutenant
Ingersoll, R. R. Lieutenant
Irvine, John, Lieutenant
Iverson, A. J. Lieut.-Commander
Jackson, J. B. Philadelphia, Pa.
Jaques, W. H. Lieutenant
Jasper, R. T. Lieutenant
Jayne, J. L. Ensign
Jenkins, F. W., Jr. Naval Cadet
Jenkins, T. A. Rear-Admiral
Jewell, T. F. Commander
Jones, H. W. Taylorsville, Va.
Jones, W. H. Surgeon
Jouett, J. E. Rear-Admiral
Prest. Board of Insp'n and Survey
Kafer, J. C. P.-Asst. Engineer
Keith, A. S. Ensign (retired)
Kellogg, Wainwright, Lieutenant
Kelly, J. P. Chief Engineer
Kennedy, Duncan, Lieutenant
Kenyon, A. J. Chief Engineer
Kimberly, L. A. Rear-Admiral
King, C. A. E. Asst. Engineer
King, W. R. Asst. Engineer
Knapp, H. S. Ensign
Knepper, C. M. Ensign
Knight, A. M. Lieutenant
Kress, Frederic N. Naval Cadet
Kutz, G. F. Chief Engineer
Laird, Chas. Lieutenant
Lawrance, J. P. S., P.-Asst. Engineer
Lawrence, F. W. Brookline, Mass.
Lee, S. P. Rear-Admiral (retired)
Lefavor, F. H. Lieutenant
Le Roy, W. E. Rear-Admiral (ret.)
Leutze, E. H. C. Lieutenant
Lillie, A. B. H. Lieutenant
Linnard, J. H. Asst. Naval Const'r
Little, W. McC. Lieutenant (retired)
Livingston, G. B., Lieut.-Commander
Lloyd, E. Ensign
Longnecker, E. Lieut.-Commander
Loring, C. H. Engineer-in-Chief
Luby, J. F. Ensign
Luce, S. B. Rear-Admiral
Lyon, H. W. Lieut.-Commander
Mackenzie, M. R. S. Lieut.-Comdr.
Macomb, D. B. Chief Engineer
Magee, G. W. Chief Engineer
Mahan, A. T. Captain
Mahan, D. H. Lieutenant
Mahoney, J. E. 2d Lt. U. S. M. C.
Manney, H. N. Lieut.-Commander
Manning, C. E. Asst. Engineer
Manning, C. H. P.-Asst. Engineer (retired)
Mansfield, H. B. Lieutenant
Marsh, C. C. Ensign
Marthon, Jos. Lieut.-Commander
Mason, N. E. Lieutenant
Matthews, E. O. Captain
Mattice, A. M. P.-Asst. Engineer
Maxwell, W. J. Ensign
Maynard, W. Lieut.-Commander
McAlister, A. A. Chaplain
McCalla, B. H. Commander
McCann, W. P. Commodore
Prest. Naval Advisory Board
McCarteney, C. M. Lieutenant
McCarty, R. H. P.-Asst. Surgeon
McCrackin, A. Lieutenant
McCrae, Henry, Lieutenant
McElroy, G. W. Asst. Engineer
McFarland, W. M. Asst. Engineer
McGowan, J. Commander
McGowan, W. C., P.-Asst. Paymaster
McGregor, C. Commander
McLane, Allan, Washington
McLean, T. C. Lieutenant
McLean, W. Lieutenant

McNair, F. V. Captain
McNary, I. R. Chief Engineer
McNutt, F. A.
McRitchie, D. G. Lieutenant
Mead, W. W. Lieut.-Commander
Menocal, A. G. Civil Engineer
Mentz, G. W. Lieutenant
Mercer, S. 1st Lt. U. S. M. C.
Merriam, G. A. Lieutenant
Merriman, E. C. Commander
Mertz, Albert, Lieutenant
Miles, C. R. Lieutenant
Miller, F. A. Lieut.-Commander
Miller, J. M. Lieutenant
Miller, J. N. Captain
Miller, J. W., Genl. Man'g'r Providence and Stonington S. Co., New York.
Miller, M. Commander
Miner, L. D. Asst. Engineer
Miner, R. H. Ensign
Mitchell, Henry, Boston
Mitchell, Richard, Lieutenant
Moore, E. K. Lieutenant
Moore, J. W. Chief Engineer
Moore, T. M. Buffalo
Morgan, Jos., Jr. Chief Engineer Cambria Iron Co., Johnstown, Pa.
Morgan, Stokely, Ensign
Morrell, H. Lieutenant
Moser, J. F. Lieutenant
Moses, F. J. 2d Lt. U. S. M. C.
Much, G. W. Naval Constructor
Mullany, J. R. M. Rear-Admiral
Mullett, T. B. Capt. U. S. R. M.
Munroe, C. E., Chemist, U. S. Torpedo Corps
Murdock, J. B. Lieutenant
Muse, W. S. Capt. U. S. M. C.
Nazro, A. P. Lieutenant
Nelson, H. C. Med. Inspector (ret.)
Nelson, V. S. Ensign
Newcomb, S., Professor, Superintendent Nautical Almanac
Newell, J. S. Lieut.-Commander
Niblack, A. P. Ensign
Nichols, F. W. Lieutenant
Nichols, H. E. Lieut.-Commander
Nichols, S. W. Commander
Nicholson, R. F. Lieutenant
Nickels, J. A. H. Lieutenant
Nicoll, W. L. Chief Engineer
Niles, N. E. Lieutenant
Nixon, L. Asst. Naval Const'r
Noel, J. E. Lieut.-Commander
Norris, G. A. Lieut.-Commander
Norton, C. F. Lieutenant
Norton, C. S. Captain
Norton, H. P. Asst. Engineer
O'Neil, C. Commander
Osterhaus, Hugo Lieutenant
Paine, S. C. Lieutenant
Parker, James, New York
Parker, J. F. Lieutenant
Parker, J. P. Ensign
Parks, W. M. P.-Asst. Engineer
Parmenter, H. E. Ensign
Patch, N. J. K. Lieutenant
Pearson, F. New York
Peary, R. E. Civil Engineer
Peck, G. Medical Director
Peck, R. G. Lieutenant
Pegram, J. C. Providence
Pendleton, E. C. Lieutenant
Perkins, H. Lieutenant
Perry, Thos. Lieut.-Commander
Phelps, T. S. Rear-Admiral
Picking, H. F. Commander
Pillsbury, J. E. Lieutenant
Plunkett, C. P. Ensign
Poe, C. C. Naval Cadet
Pook, S. H. Naval Constructor
Porter, Theodoric, Lieutenant
Potter, W. P. Lieutenant
Potts, T. M. Lieutenant
Poundstone, H. C. Ensign
Poyer, J. M. Ensign
Prime, E. S. Lieutenant
Prindle, F. C. Civil Engineer
Qualtrough, E. F. Lieutenant

Rae, C. W. P.-Asst. Engineer
Ramsay, F. M. Captain
Read, J. J. Commander
Reeder, W. H. Lieutenant
Rees, C. P. Lieutenant
Reisinger, W. W., Lieut.-Commander
Remey, G. C. Captain
Remey, W. B. Judge Adv.-General
Reynolds, E. L. New York
Rhoades, W. W., Lieut.-Commander
Rice, John Minot, S. B., Ph. D., Professor, U. S. Navy
Rittenhouse, H. O. Lieutenant
Robeson, H. B. Commander
Robie, E. D. Chief Engineer
Robinson, L. W. Chief Engineer
Rodgers, C. R. P. Rear-Admiral
Rodgers, F. Commander
Rodgers, J. A. Lieutenant
Rodgers, Raymond P., Lieutenant, In charge N. I. Office
Rodgers, T. S. Ensign
Rodgers, W. L. Ensign
Roelker, C. R. P.-Asst. Engineer
Rogers, C. C. Lieutenant
Roller, J. E. Lieutenant
Rooney, W. R. A. Lieutenant
Roosevelt, N. L. New York
Roper, Jesse M. Lieutenant
Ross, A. Lieutenant
Rowan, S. C. Vice-Admiral
Rush, R. Lieutenant
Russell, J. H., Rear-Admiral (ret.)
Rust, Armistead, Naval Cadet
Ryan, T. W. Ensign
Safford, W. E. Ensign
Salter, T. G. C. Lieutenant
Sampson, W. T., Commander, Superintendent U. S. Naval Academy
Sargent, N. Lieutenant
Savage, Thos. Boatswain
Sawyer, F. E. Lieutenant
Schaefer, H. W. Lieutenant
Schley, W. S., Commander, Chief of Bur. of Equipment and Recruiting
Schouler, J. Commander
Sebree, U. Lieutenant
Selfridge, J. R. Lieutenant
Semple, Lorenzo, Ensign
Sharp, A. Lieutenant
Sharrer, W. O. Lieutenant
Shearman, John A. Lieutenant
Shepard, E. M. Commander
Shoemaker, W. R. Ensign
Sicard, M., Captain, Chief of Bureau of Ordnance
Sigsbee, C. D. Commander
Simpson, E. Rear-Admiral (ret.)
Simpson, E. Ensign
Singer, F. Lieutenant
Skerrett, J. S. Captain
Sloan, R. S. Oswego, N. Y.
Smith, J. T. Lieutenant
Smith, R. Campbell, Ensign
Smith, S. F., St. Paul's School, Concord, N. H.
Smith, W. D. Chief Engineer
Smith, W. S. Asst. Engineer
Snow, A. S. Lieut.-Commander
Snyder, H. L. Chief Engineer
Soley, J. C. Lieutenant (retired)
Soley, J. R. Professor
Southerland, W. H. H. Lieutenant
Speel, J. N. P.-Asst. Paymaster
Sperry, C. S. Lieut.-Commander
Speyers, A. B. Lieutenant
Sprague, F. J. New York
Stahl, A. W. Asst. Engineer
Stanton, J. R. P.-Asst. Paymaster
Stanton, O. F. Captain
Stanworth, C. S. Naval Cadet
Staunton, S. A. Lieutenant
Stevens, T. H. Rear-Admiral
Stevens, T. H. Lieutenant
Stevenson, H. N., P.-Asst. Engineer
Stewart, R., Jr. Cadet Engineer
Stirling, Yates, Commander
Stockton, C. H. Lieut.-Commander
Stoney, G. M. Lieutenant
Stout, G. C.

Street, G. W. Ensign
Strong, E. T. Lieut.-Commander
Strong, W. C. Lieutenant
Sturdy, E. W. Lieutenant
Sutphen, E. W. Naval Cadet
Swinburne, Wm. T. Lieut.-Com.
Talcott, C. G. Asst. Engineer
Tallman, C. E. Sailmaker
Taussig, E. D. Lieutenant
Taylor, D. W. Asst. Naval Constr.
Taylor, H. C. Commander
Terry, N. M., A. M., Ph. D., Professor, U. S. N. A.
Terry, S. W. Commander
Thackara, A. M. Philadelphia
Thomas, C. Lieutenant
Tilley, B. F. Lieutenant
Tilton, McL. Capt. U. S. M. C.
Todd, C. C. Lieut.-Commander
Totten, G. M. Lieut.-Commander
Train, C. J. Commander
Turnbull, F. Lieutenant (retired)
Turner, T. J. Medical Director
Turner, W. H. Lieutenant
Tyler, G. W. Lieutenant
Underwood, E. B. Lieutenant
Varney, W. H. Naval Constructor
Veeder, T. E. D. W. Lieutenant
Vreeland, C. E. Lieutenant
Wadhams, A. V. Lieutenant
Wadsworth, H. Boston
Wainwright, Richard, Lieutenant
Walker, Asa, Lieut.-Commander
Walker, J. G., Captain, Chief of Bureau of Navigation
Warburton, E. T. Asst. Engineer
Waring, H. S. Lieutenant
Watson, E. W. Lieut.-Commander
Weaver, W. D. Asst. Engineer
Webb, T. E. Naval Constructor
Wells, C. H. Rear-Admiral (ret.)
Wells, Roger, Jr. Ensign
West, C. H. Lieutenant
White, E. Commander
White, W. P. Ensign
Whitham, J. M. Fayetteville, Ark.
Whittelsey, Wm. B. Ensign
Wilner, F. A. Lieutenant
Wilson, Byron, Captain
Wilson, F. A. Chief Engineer
Wilson, J. C. Lieutenant
Wilson, T. D. Chief Constructor
Winder, William, Lieutenant
Windsor, W. A. P.-Asst. Engineer
Winn, J. K. Lieut.-Commander
Winslow, F. Lieutenant
Winterhalter, A. G. Lieutenant
Wirt, W. E.
Wise, F. M. Lieutenant
Wise, Wm. C. Commander
Wolcott, C. C. Civil Engineer
Wood, E. P. Lieutenant
Wood, S. S. Ensign
Wood, W. M. Lieutenant
Woodbridge, W. E. Washington
Woodward, J. J., Asst. Naval Constr.
Woodworth, S. E. Ensign
Wooster, L. W. P.-Asst. Engineer
Worden, J. L. Rear-Admiral (ret.)
Worthington, W. F., P.-Asst. Engineer
Wright, M. F. Lieutenant
Yates, A. R. Captain

ASSOCIATE MEMBERS.—130.

Abbot, F. V., First Lieutenant Engineers, U. S. A.
Angstrom, A., C. E., Torpedo Corps.
Azoy, Anastasio, C. M., New York.
Babcock, W. T., New York.
Balbach, E., Jr., 233 River street, Newark, N. J.
Balch, G. T., Colonel, Commissioner of Accounts, New York.
Barr, F., Captain, U. S. R. M.

Bessels, E., M. D., Washington, D. C.
Bogert, J. L., Flushing Iron Works, Flushing, New York.
Bole, J. K., Otis Iron and Steel Company, Cleveland, O.
Bostrum, A. O., Navy Department, Washington, D. C.
Brooke, J. M., Professor Virginia Military Institute, Lexington, Va.
Brough, John, M. E., Vallejo, Cal.
Bulkley, Wm. F., Grand Rapids, Mich.
Burr, Edward, First Lieutenant Engineer Corps, U. S. A.
Cahill, John, People's Machine and Boiler Works, Baltimore, Md.
Campbell, J. B., Captain Fourth Artillery, U. S. A.
Chase, Constantine, First Lieutenant Third Artillery, U. S. A.
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Comly, Clifton, Major Ordnance Department, U. S. A.
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Dagron, James G., Chief Inspector of Bridges B. and O. R. R., Baltimore, Md.
Davenport, R. W., Superintendent Midvale Steel Company, Germantown, Pa.
Davies, Dayrell, Lieutenant, R. N., 26 Circus Bath, Somersetshire, England.
Davis, D. P., New York Safety Steam Power Co., 30 Courtlandt street, N. Y.
Dobson, W. A., Navy Department, Washington, D. C.
Dorsey, Edward Bates, C. E., 127 E. 23d street, New York.
Dufferin, Henry J., M. E., 209 Kent street, Brooklyn, N. Y.
Durfee, W. E., M. E., Gen. Man. U. S. Mitis Co., 26 Broadway, New York.
Dutton, S. E., San Francisco, Cal.
Edson, J. B., M. E. and C. E., 91 Liberty street, New York.
Emery, C. E., Civ. Eng., 22 Courtlandt street, New York.
Eunson, R. G., Inspector of Barlow's Insurance Surveys, 192 Broadway, N. Y.
Falsen, C. M., Lieutenant Norwegian Navy, Horten, Norway.
Farley, Arthur C., P. O. Box 1455, Boston, Mass.
Faron, E., Superintendent Morgan Iron Works, Orange, N. J.
Gatling, Dr. R., The Gatling Gun Company, Hartford, Conn.
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Greenough, G. G., Captain Fourth Artillery, U. S. A.
Grice, F. E., Navy Department, Washington, D. C.
Halsey, James T., High-Speed Automatic Engines, Richmond, Va.
Hand, S. Ashton, Hand Manufacturing Company, Toughkenamon, Pa.
Handbury, T. H., Major Engineers, U. S. A.
Hardon, Henry Winthrop, Attorney-at-Law, 52 Wall street, New York.
Harmon, O. S., 318 Monroe street, Brooklyn, N. Y.
Hartshorne, Joseph, Supt. Pottstown Iron Co., Pottstown, Pa.
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Heins, Chas. L., 13 Spruce street, New York.
Hewins, E. H., Colonel, Supt. N. E. Weston Electric Co., Boston, Mass.
Hillman, G., Naval Architect, City Island, New York.
Hills, Henry A., Secretary National Assoc. Fire Engineers, Cincinnati, O.

Hoffman, J. W., 208 S. 4th street, Philadelphia.
Hughes, R. P., Lieut.-Col., U. S. A., Insp'r-Gen'l, Presidio, San Francisco, Cal.
Humphrey, E. W. C., 412 Centre street, Louisville, Ky.
Hunt, W. P., President South Boston Iron Works, Boston.
Hyde, Marcus D., 623 Commercial street, San Francisco, Cal.
Ingalls, J. M., Captain First Artillery, U. S. A.
James, Nathl. T., 401 California street, San Francisco, Cal.
Johnson, Isaac G., C. E., Steel Manufacturer, Spuyten Duyvil, N. Y.
Kennon, L. W. V., Second Lieutenant Sixth Infantry, U. S. A.
Kent, Wm., 26 Highland street, Jersey City, N. J.
Kittelle, Geo. W., The Crescent, Eureka Springs, Ark.
Knight, Albert B., Engineer and Surveyor, Butte City, Mon.
Krupp, Alfred, Essen, Germany. (Krupp Cast-Steel Works.)
Laureau, L. G., of Gordon, Stroebel & Laureau, 226 Walnut street, Philadelphia, Pa.
Leu, Fred., 68 West street, Greenpoint, L. I.
Lieb, Charles A., Lieb Machine Works, New York.
Loring, B. W., Owego, Tioga County, N. Y.
Lyon, Henry, M. D., 34 Monument Square, Charlestown, Mass.
Macomb, M. M., First Lieutenant Fourth Artillery, U. S. A.
Mann, H. F., Pittsburgh, Pa.
Martinez, M. J., M. E., 30 Courtlandt street, New York.
Marx, J. L., Lieutenant, R. N., Arle Bury, Arlesford-Hants, England.
McLoughlan, J., 2041 Fifth avenue, New York.
Michaelis, O. E., Captain, Ordnance Department, U. S. A.
Miller, H. W., Morristown, N. J.
Miller, P. P., 293 Court street, Buffalo, N. Y.
Millis, John, First Lieutenant Engineers, U. S. A.
Mullett, A. B., Architect, 2501 Pennsylvania avenue, Washington, D. C.
Myers, T. Bailey, New York.
Nordhoff, C., Alpine, N. J.
Norton, James A., County Auditor, Tiffin, O.
Oliver, Wm. Letts, Chemist, San Francisco, Cal.
Partridge, W. E., M. E., 294 Broadway, New York.
Payson, A. H., Captain Engineers, U. S. A.
Pierce, Frank H., Mt. Carmel, Conn.
Pollok, A., 635 F street N. W., Washington, D. C.
Powell, W. T., Navy Department, Washington, D. C.
Pratt, N. W., The Babcock & Wilcox Co., 30 Courtlandt street, New York.
Quinan, W. R., Manager California Powder Works, San Francisco.
Randolph, L. S., M. E., Fernandina, Fla.
Raymond, C. W., Colonel Engineers, U. S. A.
Roepper, C. W., The Solid Steel Co., Alliance, O.
Ropes, J. C., 99 Mt. Vernon street, Boston, Mass.
Russell, A. H., Captain Ordnance, U. S. A.
Saito, M., Lieutenant Imperial Japanese Navy.

Schneider, Henri, Au Creusot, Saône-et-Loire, France.
Schuyler, M. Roosevelt, New York.
Scott, Irving M., Union Iron Works, San Francisco, Cal.
Scudder, E. M., Attorney and Counsellor, 66 Wall street, New York.
Sears, W. H., C. E., 35 Congress street, Boston, Mass.
See, Horace, Superintendent Engineer of Wm. Cramp & Sons, Philadelphia, Pa.
Shaw, A. J., 10 Pallas street, Providence, R. I.
Simpson, J. M., Captain Chilian Navy.
Sloat, Geo. V., Chief Engineer Old Diminion S. S. Co., New York.
Smedburg, W. R., Brevet Lieutenant-Colonel, U. S. A., San Francisco, Cal.
Sperry, Chas., M. E., Port Washington, L. I.
Stetson, Geo. R., M. E., New Bedford, Mass.
Stratton, E. Platt, Consulting Engineer, 38 Courtlandt street, New York.
Stueler, Rudolph, 159 Front street, New York.
Taber, H. S., Captain Engineer Corps, U. S. A.
Taylor, Harry, Second Lieutenant Engineer Corps, U. S. A.
Towne, Henry R., Stamford, Conn.
Turtle, Thomas, Captain Engineer Corps, U. S. A.
Vanderbilt, A., 113 Wall street, New York.
Webber, W. O., Superintendent Lawrence Shops, Lawrence, Mass.
Wellman, S. T., Superintendent Otis Iron Works, Cleveland, O.
West, Thos. D., Foreman Cuyahoga Foundry, Cleveland, O.
Wheeler, F. M., M. E., New York.
White, J. F., S. B., Buffalo Chemical Works, N. Y.
Willamov, G., Consul-General Russia, Bucharest, Roumania.
Williams, Albert, Principal Michigan State Mining School, Houghton, Mich.
Williams, W. B., Attorney and Counsellor, Newark, N. J.
Wilson, A. E., Lieutenant Chilian Navy.
Wisser, J. P., First Lieutenant First Artillery, U. S. A.
Woodall, James, Shipbuilder, Baltimore, Md.
Yamanouchi, M., Lieutenant Imperial Japanese Navy, Japanese Legation, Washington, D. C.
Zalinski, E. L., First Lieutenant 5th Artillery, U. S. A.

MEMBERS DECEASED SINCE JAN. 1, 1886.

Lieutenant Wm. A. Hadden, Jan. 19, 1886.
Lieut.-Commander Richard Cutts, Feb. 3, 1886.
Lieutenant H. J. Hunt, May 5, 1886.
Lieutenant H. T. Stockton, May 6, 1886.
Passed Asst. Engineer Luther R. Harvey, June 11, 1886.
General Lloyd Aspinwall, New York.
Rear-Admiral E. T. Nichols, Oct. 12, 1886.
Herman Eckel, Cincinnati, O., November, 1886.
Commodore P. C. Johnson, Jan. 28, 1887.
Lieutenant F. M. Gardner, Jan. 28, 1887.
Captain E. P. Lull, March 5, 1887.

CORRESPONDING SOCIETIES AND EXCHANGES.

United States.

American Academy of Arts and Sciences, Boston, Mass.
American Chemical Journal, Johns Hopkins University, Baltimore, Md.
American Geographical Society, New York City.
American Institute of Mining Engineers, New York City.
American Iron and Steel Association, Philadelphia, Pa.
American Metrological Society, Columbia School of Mines, New York City.
American Philosophical Society, Philadelphia, Pa.
American Society of Civil Engineers, New York City.
American Society of Mechanical Engineers, New York City.
California Academy of Sciences, San Francisco.
Connecticut Academy of Arts and Sciences, New Haven, Conn.
Franklin Institute, Philadelphia, Pa.
Geographical Society of the Pacific, San Francisco.
Journal of the Association of Engineering Societies, St. Louis, Mo.
Journal, The Railroad and Engineering, New York.
Military Service Institution of the U. S., Governor's Island, N. Y.
School of Mines Quarterly, New York City.
Sibley College, Cornell University, Ithaca, N. Y.
Technical Society of the Pacific Coast, San Francisco, Cal.

Foreign.

Association Parisienne des Propriétaires d'Appareils à Vapeur, Paris.
Canadian Institute, Toronto.
Giornale d'Artiglieria e Genio, Rome.
Hydrographisches Amt der Kaiserlichen Marine, Berlin.
Institute of Mining and Mechanical Engineers, Newcastle-on-Tyne.
Institution of Civil Engineers, London.
Institution of Mechanical Engineers, London.
Journal de la Marine—Le Yacht—Paris.
Mittheilungen a. d. Gebiete d. Seewesens, Pola.
Norsk Tidsskrift for Sovæsen, Horten, Norway.
North-east Coast Institution of Engineers and Shipbuilders, Newcastle-on-Tyne.
Revista Maritima Brazileina, Rio de Janeiro, Brazil.
Revue du Cercle Militaire Armées de Terre et de Mer, Paris.
Revue Maritime et Coloniale, Paris.
Rivista Marittima, Rome.
Royal Artillery Ipstitution, Woolwich.
Royal United Service Institution, London.
Société des Ingénieurs Civils, Paris.

SUBSCRIBERS.

"A.," H. M. S. Vernon, care Trübner & Co., London, Eng.
Artillery School, U. S., Fort Monroe, Va.

Atlantic Dynamite Co., John C. Schrader, Agent, Dover, N. J.
Bedford, Henry, Seaman U. S. R. S. Dale.
Boston Public Library, Boyleston street, Boston, Mass.
Boston Young Men's Christian Union, 18 Boyleston street, Boston, Mass.
Buffalo Library, Buffalo, N. Y.
Bureau of Construction and Repair, Navy Department, Washington, D. C.
Bureau of Navigation, Navy Department, Washington, D. C.
Bureau of Ordnance, Navy Department, Washington, D. C.
Bureau of Steam Engineering, Navy Department, Washington, D. C.
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Directeur, M. le, de l'École du Genie Maritime, 27 Quai de la Flournelle, Paris.
Du Pont, De Nemours & Co., Wilmington, Del.
Edmonds, Col. Thomas, com'g Independent Corps of Cadets, Boston, Mass.
Eyre and Spottiswoode, H. M. Printers, Great New street, London, E. C.
Falkus, Admiralty, care Trübner & Co., London.
Farmer, Moses G., Professor, Eliot, York County, Maine.
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Harlan and Hollingsworth Co., Wilmington, Del.
Harvard College Library, Cambridge, Mass.
Imperial Traveling Post-Office No. 10, Cologne, Germany.
Knabe, E., care Wm. Knabe & Co., 204 and 206 Baltimore street, Balto., Md.
Kühl, W. H., 73 Jagerstrasse, Berlin, W. Germany.
Light-House Board, Treasury Department, Washington, D. C.
Mechanics' Institute, 31 Post street, San Francisco, Cal.
Mercantile Library, Astor Place, New York.
Miami Powder Company, A. O. Fay, President, Xenia, Ohio.
Naval Academy, Library of, Annapolis, Md.
Naval Lyceum, U. S. Navy Yard, Mare Island, Cal.
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Navy Department, Washington, D. C.
Philadelphia Library Company, cor. Juniper and Locust streets, Phila., Pa.
Public Library, Chicago, Illinois.
Public Library, Detroit, Mich.
Rogers Engineering Library, University of Pennsylvania, Philadelphia, Pa.
Sailors' Hall Library, Cob Dock, Navy Yard, New York.
Steiger, E. & Co., Booksellers, 25 Park Place, New York.
Stevens Institute of Technology, Hoboken, N. J.
Union Club, 508 California street, San Francisco, Cal.
University of Michigan Library, Ann Arbor, Mich.
Virginia Military Institute, Lexington, Va.
Wallace, Wm. & Co., 131 Washington street, New York.
Watkins & Co., 10 Admiralty Place, St. Petersburg, Russia.

ANNUAL REPORT OF THE SECRETARY AND TREASURER.

To the President, Officers and Members of the Institute.

Gentlemen:—I have the honor to submit the following report of the financial and business transactions of this office during the year ending December 31, 1886. The cash statement is as follows:

Itemized Statement of Receipts During Year 1886.

Source.	1st Quarter.	2d Quarter.	3d Quarter.	4th Quarter.	Total.
Dues	$874 03	$401 00	$261 96	$369 00	$1,905 99
Life-membership fees	120 00	117 00	60 00	60 00	357 00
Subscriptions	117 75	153 50	443 80	53 60	768 65
Sales	276 77	126 15	3 00	67 50	473 42
Extra binding	22 80	2 00	1 25	4 00	30 05
Premium on exchange	14	06	.....	.....	20
Interest on bonds	18 25	9 00	9 00	42 64	78 89
	$1,429 74	$808 71	$779 01	$596 74	$3,614 20

Itemized Statement of Expenditures During Year 1886.

Item.	1st Quarter.	2d Quarter.	3d Quarter.	4th Quarter.	Total.
Postage, freight, telegraphing and incidentals	$69 79	$37 55	$30 05	$48 19	$185 58
Stationery at H. Q.	26 30	25	6 70	7 83	41 08
Messenger at H. Q.	60 00	60 00	60 00	85 00	265 00
Expenses at Branches	13 50	30 14	60	11 25	55 49
Extra binding	73 40	29 90	.....	.....	103 30
Printing publications	962 83	758 04	528 28	29 00	2,278 15
Purchase of back numbers	50 50	9 00	.....	.....	59 50
Prize Essay, 1886	.....	50 00	13 75	13 83	77 58
Advertising	4 00	.....	.....	.....	4 00
Expressage on bonds	.....	.....	1 00	.....	1 00
Purchase of D. C. bonds	174 75	242 25	.....	.....	417 00
Rebate on sales	.....	.....	.....	10 00	10 00
	$1,435 07	$1,217 13	$640 38	$205 10	$3,497 68

Balance unexpended from receipts of 1886	$116 52
Balance on hand January 1st, 1886	613 65
Total cash on hand January 1st, 1887	$730 17
Balance to credit of Reserve Fund (uninvested)	148 12
Available cash on hand January 1st, 1887	$582 05
Publisher's bill (not yet rendered)	536 00
True balance on hand January 1st, 1886	$46 05
Bills outstanding	None.
Bills receivable, outstanding dues 1885 and 1886	500 00
Publications sold late in December	37 50
Assets	$583 55

It may be noted here that five numbers have been paid for during the current year, which was one number in excess of the regular issue.

The Reserve Fund.

On January 1, 1886, there was an uninvested balance of $206.12 to the credit of this fund. During the year 1886 the Institute acquired twelve (12) new life members and fees amounting to $360, thus making a total credit to fund of $566.12. In accordance with the Constitution, a purchase of District of Columbia 3.65 per cent. bonds was made amounting to $418. Face value, $350. Bonds run till 1924. In July last the Treasurer had the $900 in United States 4 per cent. consols and $1000 in District of Columbia 3.65 per cent. bonds registered at the United States Treasury in the name of the U. S. Naval Institute. The registered bonds and $350 in 3.65 per cent. District of Columbia bonds are deposited in the vault of the Farmers' National Bank of Annapolis for safekeeping.

Total face value of bonds in Reserve Fund, $2250. The interest only of this fund is available for current expenses, the principal being held in perpetuity to guarantee the future interests of the Institute, and of the life members in particular.

Meetings and Publications, 1886.

During the calendar year 1886 nine meetings of the Institute took place at Annapolis, and a number at Washington, New York, Newport, and Norfolk.

The quarterly publications have, in accordance with the plan adopted by the Board of Control, appeared as early in the quarter as

practicable, No. 36 in February, No. 37 in April, No. 38 in July, and finally, No. 39 in December, thus forming a volume (No. XII.) of 661 printed pages (not including appendices, notices and plates).

Publications on Hand.

The Institute has on hand back publications as follows:

	Copies Plain.	Copies Bound.		Copies Plain.	Copies Bound.
No. 1	218	...	No. 21	245	...
2	261	...	22	289	...
3	78	...	23	200	...
4	170	...	24	218	...
5	139	...	25	1176	47
6	20	...	26	221	77
7	27	...	27	307	27
8	53	...	28	14	4
9	57	...	29	234	27
10	16	...	30	264	5
11	233	...	31	82	58
12	73	...	32	7	184
13	12	...	33	27	165
14	9	...	34	80	14
15	5	...	35	125	67
16	237	...	36	265	30
17	4	...	37	190	26
18	106	...	38	242	...
19	122	...	39	289	...
20	140	...			

The archive set complete, Vol. I. to Vol. XII. inclusive, bound in full turkey, and seven copies Vol. X. in two parts in half turkey.

Jno. W. Danenhower, Lieut., U. S. N.,
Secretary and Treasurer.

CONSTITUTION AND BY-LAWS.

ARTICLE I.—TITLE.

This organization shall be called the United States Naval Institute.

ARTICLE II.—OBJECT.

Its object is the advancement of professional, literary, and scientific knowledge in the Navy.

ARTICLE III.—HEADQUARTERS.

The Headquarters of the Institute shall be at the United States Naval Academy, Annapolis, Md.

ARTICLE IV.—OFFICERS.

The officers shall be as follows:

A President.

A Vice-President.

A Board of Control.

A Secretary and Treasurer.

A President and Corresponding Secretary for each Branch.

ARTICLE V.—ELECTION OF OFFICERS.

SEC. 1. There shall be a meeting of the Institute at Headquarters on the second Friday in October of each year, of which at least two weeks' notice shall be given, at which meeting all the foregoing officers, except those of Branches, shall be elected by ballot in open session, and a majority of votes given by presence or proxy shall elect; regular or life members only being eligible for office.

SEC. 2. Absent members who have the constitutional right to vote may vote by proxy at such elections, and in the same manner on all questions involving changes in the Constitution and By-Laws, and upon questions involving the expulsion of members and the election of honorary members. On all other questions voting must be by actual presence. Life members shall have the full right of regular members to vote on every question. Honorary and associate

members shall not have the privilege of voting. All proxies must be signed by the member whose vote is to be represented.

SEC. 3. Members elected to the position of officers of the Institute will assume their respective duties at the date from which elected.

SEC. 4. Casual vacancies in the officers of the Institute may be temporarily filled by the Board of Control.

ARTICLE VI.—DUTIES OF OFFICERS.

SEC. 1. The President shall preside at business meetings of the Institute, or its Branches, at which he may be present.

SEC. 2. In the absence of the President at Headquarters, the Vice-President shall preside.

SEC. 3. The Board of Control shall consist of seven members in good standing, regular or life, and its duties shall be the management of all the financial and administrative business of the Institute, including the censorship, printing, and control of its publications. The Secretary and Treasurer shall be, *ex officio*, a member of the Board, its medium of communication and the recorder of its transactions. The regular meetings of the Board of Control shall be held upon the first and third Saturday of each month. A special meeting shall be called by the Secretary and Treasurer upon the written application of two members of the Board. A quorum shall consist of three members. In the absence of both the President and Vice-President at business meetings of the Institute, a member of the Board of Control shall preside. It shall be the duty of this Board to appoint a committee of three of its own members to audit and certify the books and accounts of the Secretary and Treasurer at least once every quarter.

SEC. 4. The Secretary and Treasurer shall keep a register of the members in which shall be noted all changes; an authenticated copy of the Constitution and By-Laws in force; a journal of the Proceedings of the Institute; a separate journal of the transactions of the Board of Control; a receipt and expenditure book; an account-current with each member. Under the authority of the Board of Control, he shall be the disbursing and purchasing officer of the Institute and the custodian of the funds, securities, and assets, and it shall be his duty to furnish members with receipts for dues paid. He shall attend to all correspondence and keep a record thereof, give due notice of meetings of the Institute and Board of Control, have charge of the stenographer and copyists employed to prepare records of the

Proceedings, and he shall distribute all publications. The books of account of the Institute shall always be open to inspection by any member. Papers accepted by the Board of Control shall be read by the Secretary and Treasurer when the author cannot be present.

ARTICLE VII.—MEMBERSHIP.

SEC. 1. The Institute shall consist of regular, life, honorary, and associate members.

SEC. 2. Officers of the Navy, Marine Corps, and all civil officers attached to the Naval Service, shall be entitled to become regular or life members, without ballot, on payment of dues or fees to the Secretary and Treasurer, or to the Corresponding Secretary of a Branch. Members who resign from the Navy subsequent to joining the Institute will be regarded as belonging to the class described in this Section.

SEC. 3. The Prize Essayist of each year shall be a life member without payment of fee.

SEC. 4. Honorary members shall be selected from distinguished Naval and Military Officers, and from eminent men of learning in civil life. The Secretary of the Navy shall be, *ex officio*, an honorary member. Their number shall not exceed thirty (30). Nominations for honorary members must be favorably reported by the Board of Control, and a vote equal to one-half the number of regular and life members, given by proxy or presence, shall be cast, a majority electing.

SEC. 5. Associate members shall be elected from officers of the Army, Revenue Marine, foreign officers of the Naval and Military professions, and from persons in civil life who may be interested in the purposes of the Institute.

SEC. 6. Those entitled to become associate members may be elected life members, provided that the number not officially connected with the Navy and Marine Corps shall not at any time exceed one hundred (100).

SEC. 7. Associate members and life members, other than those entitled to regular membership, shall be elected as follows: Nominations shall be made in writing to the Secretary and Treasurer, with the name of the member making them, and such nominations shall be submitted to the Board of Control, and, if their report be favorable, the Secretary and Treasurer shall make known the result at the next

meeting of the Institute, and a vote shall then be taken, a majority of votes cast by members present electing.

SEC. 8. The annual dues for regular and associate members shall be three dollars, payable upon joining the Institute, and upon the first day of each succeeding January. The fee for life membership shall be thirty dollars, but if any regular or associate member has paid his dues for the year in which he wishes to be transferred to life membership, or has paid his dues for any future year or years, the amount so paid shall be deducted from the fee for life membership.

SEC. 9. No member of the Institute shall be dismissed except by recommendation of the Board of Control, and by a two-thirds vote of the members of the Institute voting at any regular or called meeting, of which at least one month's notice shall be given. Without the recommendation of the Board of Control, no member can be dismissed except by a three-fourths vote. In both the above cases there must be a total vote of at least a majority of all those members entitled to a vote, the voting to be either by presence or proxy. Members two years in arrears shall be dropped. Those dropped for non-payment of dues can regain their membership by paying two years' arrearage of dues, but the Board of Control may adjust any special case upon its merits.

ARTICLE VIII.—RESERVE FUND.

The amount now invested ($2250) in United States and District of Columbia bonds shall be placed to the credit of a Reserve Fund. All moneys received from life-membership fees shall, as soon as practicable, be invested in United States bonds, or bonds guaranteed by the United States, and shall be added to said fund, which shall be held in perpetuity to guarantee the future interest of said life members. The interest of said fund may, however, be used for the current expenses of the Institute.

ARTICLE IX.—MEETINGS.

SEC. 1. The regular time of holding meetings of the Institute shall be the second Friday of each month, but if there should be no paper accepted by the Board of Control to be read, professional subject to be discussed, or executive business to be transacted, the monthly meeting may be omitted.

SEC. 2. Special meetings of the Institute shall be called by the Secretary and Treasurer when directed by the Board of Control.

SEC. 3. Notice of regular or special meetings shall state the title of papers to be read, with the name of the author, and mention the executive business that will be brought before the meeting.

SEC. 4. A stenographer may be employed when authorized by the Board of Control.

ARTICLE X.—PAPERS AND PROCEEDINGS.

SEC. 1. Quarterly, or as much oftener as the Board of Control may decide, the papers read before the Institute and its Branches, together with the discussions growing out of them, shall be published. Papers on intricate technical subjects of such a character as not to be appreciated on merely casual investigation, and articles too extended to be read at one meeting of the Institute, may be published as a part of the Proceedings when authorized by the Board of Control; and there may also be published, under the heads of Editorial and Professional Notes, such comment and information as may be deemed of value to the service.

SEC. 2. One copy of the Proceedings, when published, shall be furnished to each regular, life, honorary, and associate member, to each corresponding Society of the Institute, and to such libraries and periodicals as may be determined upon by the Board of Control.

SEC. 3. Copies of the Proceedings and complete sets may be sold at a charge fixed by the Board of Control, and the Board shall also fix the price of annual subscription for others than members.

SEC. 4. A receipt and expenditure account of the Institute's publications, showing the number on hand, shall be included in the report of the Secretary and Treasurer of each year.

SEC. 5. The Board of Control shall decide the size of the edition of each number of the Proceedings to be published, and also the number of reprints.

ARTICLE XI.—ANNUAL PRIZE ESSAY.

SEC. 1. A Prize of at least one hundred dollars, with a gold medal, shall be offered each year for the best essay on any subject selected by the Board of Control.

SEC. 2. The award for the above-named Prize shall be made by a board of three competent and disinterested judges appointed by the Board of Control, and the time and manner of submitting such essays shall be determined and announced by said Board.

SEC. 3. In the event of the Prize being awarded to the winner of a previous year, a gold clasp, suitably engraved, will be given in lieu of a gold medal.

ARTICLE XII.—BRANCHES.

SEC. 1. The Board of Control is empowered to appoint Corresponding Secretaries for all Naval Stations, both ashore and afloat, where there is no organized Branch; also for Branches where a vacancy exists owing to the resignation of the Corresponding Secretary before a meeting can be called to elect a successor.

SEC. 2. The officers of a Branch shall be a Vice-President and a Corresponding Secretary.

SEC. 3. The Vice-President shall perform the same duty for the Branch as prescribed for the President of the Institute.

SEC. 4. The Corresponding Secretary of a Branch shall keep a register of the members residing within the limits of the Station, and an account-current with each. He shall keep a journal of the proceedings of the Branch and a copy of the Constitution and By-Laws. He shall give due notice of all meetings of the Branch, and shall have control of the stenographer whenever it is deemed necessary to employ one. He shall forward to the Secretary and Treasurer of the Institute all papers read before his Branch, and keep him informed of all new members and their addresses, and of all business relating to the Institute. He shall have charge of the Branch library and of all books and papers, and shall receive and distribute publications. He shall keep a receipt and expenditure book, shall collect dues from members on the Station and give receipts therefor. He shall be authorized to expend such part of the funds in his possession for stationery, postage, printing, and for other incidental expenses as may be deemed necessary. He shall at the end of each month render to the Secretary and Treasurer a detailed statement of moneys received and expended, with vouchers for expenditures, and shall forward to the Secretary and Treasurer the funds remaining on hand, retaining only sufficient to defray the estimated current expenses of the Branch for the ensuing month.

SEC. 5. Monthly meetings of each Branch may be held upon such dates as the Branch shall decide, but if there is no paper to be read or business to be transacted at the appointed date, the Corresponding Secretary may omit the call for the regular meeting. Special meetings may be called when necessary.

ARTICLE XIII.—Copyright.

The Proceedings shall be copyrighted in behalf of the Institute by the Secretary and Treasurer.

ARTICLE XIV.—Amendments.

No addition or amendment to the Constitution shall be made without the assent of two-thirds of the members voting; the By-Laws, however, may be amended by a majority vote. Notice of proposed changes or additions shall be given by the Secretary and Treasurer at least one month before action is taken upon them. A total vote equal to at least half the number of regular and life members shall be required.

BY-LAWS.

ARTICLE I.

The rules of the United States House of Representatives shall, in so far as applicable, govern the parliamentary proceedings of the Society.

ARTICLE II.

1. At both regular and stated meetings the routine of business shall be as follows:

2. At executive meetings, the President, or, in his absence, the Vice-President, or, in the absence of both, a member of the Board of Control, shall call the meeting to order, and occupy the chair during the session; in the absence of these, the meeting shall appoint a Chairman.

3. At meetings for the presentation of papers and discussion, the Society shall be called to order as above provided, and a Chairman shall be appointed by the presiding officer, reference being had to the subject about to be discussed, and an expert in the specialty to which it relates being selected.

4. At regular meetings, after the presentation of the paper of the evening, or on the termination of the arguments made by members appointed to or voluntarily appearing to enter into formal discussion, the Chairman shall make such review of the paper as he may deem proper. Informal discussion shall then be in order, each speaker

being allowed not exceeding ten minutes in the aggregate, unless by special consent of the Society. The author of the paper shall, in conclusion, be allowed such time in making a résumé of the discussion as he may deem necessary. The discussion ended, the Chairman shall close the proceedings with such remarks as he may be pleased to offer.

5. At the close of the concluding remarks of the Chairman, the Society shall go into executive session, as hereinbefore provided, for the transaction of business as follows:

1. Stated business, if there shall be any to be considered.
2. Unfinished business taken up.
3. Reports of Officers and Committees.
4. Applications for membership reported and voted upon.
5. Correspondence read.
6. Miscellaneous business transacted.
7. New business introduced.
8. Adjournment.

NAVAL INSTITUTE PRIZE ESSAYS, 1879–1888.

1879.

Subject:—"NAVAL EDUCATION.—I. OFFICERS. II. MEN."

Judges of Award:—CHARLES W. ELLIOT, President of Harvard University; DANIEL AMMEN, Rear-Admiral, U. S. N.; WM. H. SHOCK, Engineer-in-Chief, U. S. N.

Winner of the Prize:—Lieutenant-Commander ALLAN D. BROWN, U. S. N. *Motto of Essay:*—"Qui non proficit."

First Honorable Mention:—Lieutenant-Commander CASPAR F. GOODRICH, U. S. N. *Motto of Essay:*—"Esse quam videri."

Second Honorable Mention:—Commander ALFRED T. MAHAN, U. S. N. *Motto of Essay:*—"Essayons."

Number of Essays presented for competition, ten.

1880.

Subject:—"THE NAVAL POLICY OF THE UNITED STATES."

Judges of Award:—Hon. WM. M. EVARTS, Secretary of State; Hon. R. W. THOMPSON, Secretary of the Navy; Hon. J. R. MCPHERSON, U. S. Senator.

Winner of the Prize:—Lieutenant CHARLES BELKNAP, U. S. N. *Motto of Essay:*—"Sat cito, si sat bene."

Number of Essays presented for competition, eight.

1881.

Subject:—"THE TYPE OF (I.) ARMORED VESSEL, (II.) CRUISER, BEST SUITED TO THE PRESENT NEEDS OF THE UNITED STATES."

Judges of Award:—Commodore W. N. JEFFERS, U. S. N.; Chief Engineer J. W. KING, U. S. N.; Chief Constructor JOHN LENTHALL, U. S. N.

Winner of the Prize by decision of two of the Judges:—Lieutenant EDWARD W. VERY, U. S. N. *Motto of Essay:*—"Aut Cæsar, aut nullas."

Recommended for the Prize by one of the Judges:—Lieutenant SEATON SCHROEDER, U. S. N. *Motto of Essay:*—"In via virtute via nulla."

Number of Essays presented for competition, four.

1882.

Subject:—"Our Merchant Marine; the Causes of its Decline and the Means to be taken for its Revival."

Judges of Award:—Hon. Hamilton Fish, Ex-Secretary of State; John D. Jones, President Atlantic Mutual Insurance Company, New York; A. A. Lowe, Ex-President New York Chamber of Commerce.

Winner of the Prize:—Lieutenant James D. J. Kelley, U. S. N. *Motto of Essay:*—"Nil clarius aquis."

First Honorable Mention:—Master Carlos G. Calkins, U. S. N. *Motto of Essay:*—"Mais il faut cultiver notre jardin."

Second Honorable Mention:—Lieutenant-Commander F. E. Chadwick, U. S. N. *Motto of Essay:*—"Spero meliora."

Third Honorable Mention:—Lieutenant Richard Wainwright, U. S. N. *Motto of Essay:*—"Causa latet: vis est notissima."

Essay printed by request of John D. Jones, Esq.—Ensign W. G. David, U. S. N. *Motto of Essay:*—"Tempori parendum."

Number of Essays presented for competition, eleven.

1883.

Subject:—"How may the Sphere of Usefulness of Naval Officers be Extended in Time of Peace with Advantage to the Country and the Naval Service?"

Judges of Award:—Hon. Alexander H. Rice; Judge Josiah G. Abbott; Rear-Admiral George H. Preble, U. S. N.

Winner of the Prize:—Lieutenant Carlos G. Calkins, U. S. N. *Motto of Essay:*—"Pour encourager les autres."

First Honorable Mention:—Commander N. H. Farquhar, U. S. N. *Motto of Essay:*—"Semper paratus."

Second Honorable Mention:—Captain A. P. Cooke, U. S. N. *Motto of Essay:*—"Cuilibet in arte suâ credendum est."

Number of Essays presented for competition, four.

1884.

Subject:—"The Best Method for the Reconstruction and Increase of the Navy."

Judges of Award:—Rear-Admiral C. R. P. Rodgers, U. S. N.; D. C. Gilman, LL. D., President of the Johns Hopkins University; Hon. J. R. Hawley, U. S. Senator.

Winner of the Prize:—Ensign W. I. Chambers, U. S. N. *Motto of Essay:*—"Thou too, sail on, O Ship of State."

Number of Essays presented for competition, two.

1885.

Subject:—"INDUCEMENTS FOR RETAINING TRAINED SEAMEN IN THE NAVY AND THE BEST SYSTEM OF REWARDS FOR LONG AND FAITHFUL SERVICE."

Judges of Award:—Rear-Admiral THORNTON A. JENKINS, U. S. N.; Commander W. S. SCHLEY, U. S. N., Chief of Bureau of Equipment and Recruiting, Navy Department, Washington, D. C.; and Captain JOHN CODMAN, of New York City.

Winner of the Prize:—Commander NORMAN H. FARQUHAR, U. S. N. *Motto of Essay*:—"Ut prosim."

Number of Essays presented for competition, three.

1886.

Subject:—"WHAT CHANGES IN ORGANIZATION AND DRILL ARE NECESSARY TO SAIL AND FIGHT MOST EFFECTIVELY OUR WAR SHIPS OF THE LATEST TYPE?"

Judges of Award:—Rear-Admiral E. SIMPSON, U. S. N., President of Board of Inspection; Captain MONTGOMERY SICARD, U. S. N., Chief of Bureau of Ordnance; and Captain AUGUSTUS P. COOKE, U. S. N., Commanding U. S. R. S. Vermont.

Number of Essays presented for competition, seven.

These Essays are now in the hands of the Judges, and the award will soon be made.

1887.

Subject:—"THE NAVAL BRIGADE—ITS ORGANIZATION, EQUIPMENT, AND TACTICS."

1888.

See Special Notice on last page.

PROCEEDINGS

OF THE

UNITED STATES NAVAL INSTITUTE,

ANNAPOLIS, MD.

CONTENTS VOLUMES I. TO XIII., No. 1, INCLUSIVE.

(WHOLE NOS. 1 TO 40.)

Classified and Arranged Alphabetically.

ARCTIC VOYAGES.

Alliance in Search of the Jeannette, The Cruise of the. By Lieutenant C. P. Perkins, U. S. N. Vol. XI., No. 4, p. 701.

Polar Question, The. By Lieutenant John W. Danenhower, U. S. N. Vol. XI., No. 4, p. 633.

Same. Discussion of. By Sir Geo. S. Nares, K. C. B., F. R. S., Captain R. N.; Chief Engineer Geo. W. Melville, U. S. N.; Lieutenant A. W. Greely, U. S. A.; Dr. H. Rink, Ex-Governor of Greenland; Professor J. E. Nourse, U. S. N.; Captain Carl Koldewey, Commander of the Germania Expedition, and Lieutenant Jno. W. Danenhower, U. S. N.; Remarks by Clements R. Markham, C. B., F. R. S., Secretary of Royal Geographical Society, London, in the chair. Vol. XI., No. 4, pp. 686-699.

Smith Sound and Its Explorations. By Dr. Emil Bessels. Vol. X., No. 3, p. 333.

Tigress, The Cruise of the. By Lieutenant-Commander H. C. White. Vol. I., No. 1, p. 39.

Same. Discussion of. Vol. I., No. 1, p. 55.

ARMAMENT.

Alarm, The U. S. S. By Lieutenant R. M. G. Brown, U. S. N. Vol. V., No. 5, p. 499.

Same. Discussion of. Vol. V., No. 5, p. 511.

Navy, Armament for the. By Commodore E. Simpson, U. S. N. Vol. VII., No. 2, p. 165.

Ships of War, The Armament of Our. By Captain W. N. Jeffers, U. S. N. Vol. I., No. 1, p. 105.

Trenton, The U. S. S., General Description of the Ordnance and Torpedo Outfit of. By Lieutenant C. A. Stone, U. S. N. Vol. III., No. 1, p. 89.

ARMOR.

Armor as Applied to Ships, The Development of. By Lieutenant Jacob W. Miller, U. S. N. Vol. V., No. 5, p. 513.

Armor, Deflecting. By Passed-Assistant Engineer N. B. Clark, U. S. N. Vol. VII., No. 1, p. 1.

Armor, Deflecting. Professional Note. By Passed-Assistant Engineer N. B. Clark, U. S. N. Vol. VII., No. 2, p. 183.

Armor, Distribution of, in Ships of War. By Assistant Naval Constructor W. E. Smith, R. N. Professional Note. Vol. XI., No. 4, p. 777.

Armor for Naval Use, The Development of. By Lieutenant E. W. Very, U. S. N. Vol. IX., No. 3, pp. 349–591.

Gun-Shields for Cruisers, Water-Line Defense and. By Passed-Assistant Engineer N. B. Clark, U. S. N. Vol. IX., No. 5, p. 713.

Monitor, A Modified, with a New Method of Mounting and Working the Guns. By Ensign W. I. Chambers, U. S. N. Vol. VII., No. 4, p. 437.

Protective Deck, The Steamer Union and the Origin of the. Professional Note. Vol. XI., No. 1, p. 147.

Wrought-Iron Plates, On the Laws of Penetration of. Professional Note. Vol. XI., No. 2, p. 341.

BOATS.

Lowering [illegible] in Any Weather, Portuguese Automatic Apparatus for. Translated by Ensign Albert G. [illegible], U. S. N. Vol. X., No. 3, p. 519.

Rigs for Boats and Launches, Discussion on a Uniform System of. Vol. VI., No. 1, p. 41.

Submarine Boats. Professional Note. Vol. XII., No. 3, p. 439.

CIVIL ENGINEERING.

Channel Improvement, Washington Navy Yard. By Civil Engineer A. G. Menocal, U. S. N. Vol. VIII., No. 4, p. 627.

Docking Facilities in Our Navy Yards, The Want of. By Civil Engineer U. S. G. White, U. S. N. Vol. VI., No. 3, p. 265.

Mud Docks at Vizagapatam, India. Professional Note. Vol. X., No. 2, p. 318.

DRILLS.

Landing Exercise, U. S. S. Swatara, 1882. Professional Note. Vol. VIII., No. 3, p. 499.

March to Witu, Extract from the Report of the. Translated by Lieutenant W. H. Beehler, U. S. N. Vol. XII., No. 4, p. 625.

Naval Brigade, The. By Lieutenant J. C. Soley, U. S. N. Vol. VI., No. 3, p. 265.

Service Exercises, Suggestions in Favor of More Practical. By Lieutenant N. E. Sargent, U. S. N. Vol. X., No. 2, p. 233.

EDUCATION AND TRAINING.

How May the Sphere of Usefulness of Naval Officers be Extended in Time of Peace with Advantage to the Country and the Naval Service? Prize Essay, 1883. By Lieutenant Carlos G. Calkins, U. S. N. Vol. IX., No. 2, p. 155.

Same. Honorably Mentioned. By Commander N. H. Farquhar, U. S. N. Vol. IX., No. 2, p. 195.

Same. Honorably Mentioned. By Commander A. P. Cooke, U. S. N. Vol. IX., No. 2, p. 203.

Same. Discussion of. Vol. X., No. 2, p. 241.

Minnesota, The Training Ship. By Lieutenant B. Noyes, U. S. N. Vol. VI., No. 1, p. 99.

Natural History, Post-Graduate Instruction in, for Naval Officers. By Professor C. E. Munroe. Vol. VIII., No. 1, p. 191.

Naval Education. Prize Essay, 1879. By Lieutenant-Commander A. D. Brown, U. S. N. Vol. V., No. 4, p. 305.

Same. Honorably Mentioned. By Lieutenant-Commander C. F. Goodrich, U. S. N. Vol. V., No. 4, p. 323.

Same. Honorably Mentioned. By Commander A. T. Mahan, U. S. N. Vol. V., No. 4, p. 345.

Same. Discussion of. Vol. V., No. 4, p. 377.

Responsibility. Professional Note. Vol. IX., No. 2, p. 335.

Seamen, The Training of. By Lieutenant-Commander Chadwick, U. S. N. Vol. VI., No. 1, p. 15.

War Schools. By Commodore S. B. Luce, U. S. N. Vol. IX., No. 5, p. 633.

ELECTRICITY.

Dynamo Machine and Electric Light, The Naval Use of the. By Lieutenant J. B. Murdock, U. S. N. Vol. VIII., No. 3, p. 343.

Dynamo Machines, Test of, at Paris Exhibition, 1881. Professional Note. Vol. IX., No. 1, p. 137.

Electricity Applied to Explosive Purposes. By Sir Frederick A. Abel. Professional Note. Vol. IX., No. 5, p. 767.

Electric Light, The Edison, on Board the U. S. Fish Commission Steamer Albatross. Professional Note. Vol. X., No. 2, p. 313.

Electrical Testing and Measuring Apparatus for Ships, Notes on. By Ensign S. Dana Greene, U. S. N. Vol. XII., No. 4, p. 483.

Submarine Telegraph Work, The Tactics of. By Passed-Assistant Engineer Thomas W. Rae, U. S. N. Vol. II., No. 1, p. 33.

EXPLOSIVES.

Blasting-Gelatine and Gelatine-Dynamite. Professional Note. Vol. VII., No. 4, p. 486.

Bomb that Killed the Czar, The. Professional Note. Vol. VII., No. 2, p. 187.

Compressed Gun-Cotton: Its Use in Shell. Translated by Lieutenant Karl Rohrer, U. S. N. Vol. XII., No. 4, p. 563.

Dynamite, Breaking up Old Guns by. Professional Note. Vol. VI., No. 4, p. 397.
Dynamite, Gum. Professional Note. Vol. VII., No. 4, p. 483.
Explosions, An Experimental Lecture upon the Causes and Conditions which Promote. By Professor Charles E. Munroe. Vol. IV., No. 1, p. 21.
Explosives, Notes on the Literature of. By Professor C. E. Munroe. I. Vol. VIII., No. 2, p. 297.
Same. II. Vol. VIII., No. 3, p. 439.
Same. III. Vol. VIII., No. 4, p. 657.
Same. IV. Vol. IX., No. 2, p. 287.
Same. V. Vol. IX., No. 5, p. 735.
Same. VI. Vol. X., No. 2, p. 203.
Same. VII. Vol. XI., No. 1, p. 85.
Same. VIII. Vol. XI., No. 2, p. 275.
Same. IX. Vol. XI., No. 4, p. 763.
Same. X. Vol. XII., No. 2, p. 179.
Same. XI. Vol. XII., No. 3, p. 423.
Same. XII. Vol. XII., No. 4, p. 603.
Gelatine, Explosive. Professional Note. Vol. VII., No. 4, pp. 473–483.
Gum-Dynamite or Explosive Gelatine, Notes on. By Professor C. E. Munroe. Vol. V., No. 1, p. 21.
Gunpowder, Combustion of, in Guns. By Lieutenant J. F. Meigs, U. S. N. Vol. XI., No. 2, p. 321.
Gunpowder Magazines, The Drying of. By Professor C. E. Munroe. Professional Note. Vol. IX., No. 2, p. 332.
Gunpowder, On the Recent Modifications of the Explosive Force of. By Lieutenant-Commander W. M. Folger, U. S. N. Vol. V., No. 2, p. 99.
Gunpowder, The Chemical Theory of the Combustion of. Translated by Professor C. E. Munroe. Vol. V., No. 5, p. 538.
Gunpowder, The Chemical Theory of. By H. Debus, Ph. D., F. R. S. Vol. IX., No. 1, p. 1.
Gunpowder, The Use of Steam in the Manufacture of. Extract from *Am. Chem. Journal*. Vol. VII., No. 2, p. 182.
High Explosives from Great Guns, The Firing of. By Commander Albert S. Barker, U. S. N. Vol. XII., No. 4, p. 547.
Nitroglycerine, Notes on. By Professor C. E. Munroe. Vol. V., No. 1, p. 5.
Nitroglycerine, Note on the Manufacture of, at Vouges. By Professor C. E. Munroe. Vol. V., No. 2, p. 141.
Powder, Researches on the Effects of. By M. E. Sarrau, Ingénieur des Poudres et Salpêtres. Translated by Lieutenants J. F. Meigs and R. R. Ingersoll, U. S. N. Vol. X., No. 1, pp. 1–170.
Small-Arm Powder, Trials of. Professional Note. Vol. XII., No. 4, p. 642.

HISTORY.

Battle of Oct. 9, between the Chilian Fleet and Peruvian Ram Huascar, off Pt. Tetas. Translated from Official Reports. Vol. V., No. 5, p. 563.

Cruise of Columbus in the Bahamas, 1492. By Lieutenant J. B. Murdock, U. S. N. Vol. X., No. 3, p. 449.

Egyptian Campaign, 1882, Operations of the British Navy and Transport Service. Vol. VIII., No. 4, pp. 523–623. A Series of Papers from Various Sources, as follows:

The Bombardment of Alexandria. By Ensign Charles C. Rogers, U. S. N., ... 523

Official Report of Bombardment of Alexandria. By Admiral Sir Beauchamp Seymour, ... 540

The Defenses of Alexandria and the Damage Resulting from the Bombardment. By Ensign Thomas D. Griffin, U. S. N., . . 545

The Result of the Bombardment of Fort Mex, Alexandria. Preparations for Flooding Lake Mareotis. By Ensign Albert Gleaves, U. S. N., ... 549

Results of the Bombardment of Forts Ras-el-tin, Ada, and Pharos, Alexandria. By Ensign Charles M. McCarteney, U. S. N. . . 560

The Navy and Marines on Shore, ... 566

Mounting of Guns at Ramleh, ... 570

The English Naval Brigade and Batteries in Egypt. By Lieutenant Charles F. Norton, U. S. N., ... 571

Armored Train Used by the Forces at Alexandria. By Lieutenant Nathan H. Barnes, U. S. N., ... 574

The Seizure of the Suez Canal, ... 577

Lord Charles Beresford on Machine Guns, ... 585

Memoranda, ... 588

Details in Regard to the Transport Service for Egypt, . . . 597

Troops Transported to Egypt. Headquarters and Staff of Corps, Divisions, Brigades, etc., ... 600

Material Transported to Egypt, ... 606

Transports. By Lieutenant Albion V. Wadhams, U. S. N., . . 615

Hospital Service of Army in Egypt. Water Supply of Alexandria. By Surgeon John W. Coles, U. S. N., ... 619

Subsistence of Soldiers, Sailors and Marines in Egypt. By Paymaster Jonathan Q. Barton, U. S. N., ... 620

Sir Garnet Wolseley's Instructions, ... 622

The New Peers, ... 623

Farragut in the Hartford's Rigging at Mobile: Three Letters Concerning a Disputed Fact. Professional Note. Vol. VI., No. 3, p. 303.

Fleets of the World. By Captain S. B. Luce, U. S. N. Vol. III., No. 1, p. 5.

Fleets of the World. By the late Commodore F. A. Parker, U. S. N. Vol. VI., No. 4, p. 313.

Huascar, Details Concerning the Capture of. Professional Note. Vol. VI., No. 3, p. 295.

Mediterranean Squadron under Commodore Preble in 1803–4, Operations of the. By Professor James Russell Soley, U. S. N. Vol. V., No. 2, p. 51.

Mexico, The War with: The Cruise of the U. S. S. Cyane during the Years 1845–48. From Papers of the Commander, the late Rear-Admiral S. F. Dupont, U. S. N. Vol. VIII., No. 3, p. 419.

Min River, Combats on the. Translated from the French by Lieutenant E. B. Barry, U. S. N. Vol. XI., No. 2, p. 295.

Monitor and the Merrimac, The. By Commodore F. A. Parker, U. S. N. Vol. I., No. 1, p. 155.

Monitor Weehawken in the Rebellion. By B. W. Loring, Late Lieutenant U. S. N. Vol. XII., No. 2, p. 111.

Naval Campaign of 1812, The. By Professor J. R. Soley, U. S. N. Vol. VII., No. 3, p. 297.

War in South America, The. By Lieutenant J. F. Meigs, U. S. N. Vol. V., No. 5, p. 461.

HYGIENE.

Air-Refrigerating Machine. Professional Note. Vol. X., No. 2, p. 285.

Circulating and Heating Water, Drainage and Ventilation of Staterooms, etc., on Shipboard, Proposed System for. By Passed-Assistant Engineer Stacy Potts, U. S. N. Vol. VIII., No. 2, p. 247.

Environment of the Man of the Sea. By Medical Inspector B. F. Gibbs, U. S. N. Vol. V., No. 4, p. 407.

Hygiene, Naval, Discussion on. Vol. VI., No. 3, p. 349.

Hygiene, Naval, Museum of. Professional Note. Vol. IX., No. 2, p. 328.

Hygienic Notes on Ships' Bilges. By Lieutenant-Commander C. F. Goodrich, U. S. N. Vol. II., No. 1, p. 93.

Sanitary Commonplaces Applied to the Navy. By Medical Inspector A. L. Gihon, U. S. N. Vol. II., No. 1, p. 111.

Ships, Supplement to Article on the Ventilation of. By Passed-Assistant Engineer G. W. Baird, U. S. N. Vol. VI., No. 3, p. 348.

Ships, The Ventilation of. By Passed-Assistant Engineer G. W. Baird, U. S. N. Vol. VI., No. 3, p. 237.

Testing Water on Board Ship. By Lieutenant-Commander Horace Elmer, U. S. N. Vol. V., No. 4, p. 433.

INTEROCEANIC CANAL.

Interoceanic Canal, The. By Lieutenant Fred. Collins, U. S. N. Vol. II., No. 1, p. 21.

Same. Discussion of. Vol. II., No. 1, p. 31.

Isthmus of Darien and Valley of the Atrato Considered with Reference to the Practicability of an Interoceanic Canal. By Lieutenant Fred. Collins, U. S. N. Vol. I., No. 1, p. 123,

Same. Discussion of. Vol. I., No. 1, p. 179.

Nicaragua Ship Canal, Notes on. By Ensign W. I. Chambers, U. S. N. Professional Note. Vol. XI., No. 4, p. 807.

Nicaragua Survey. By Lieutenant J. W. Miller, U. S. N. Vol. IV., No. 1, p. 65.

LAW.

Courts-Martial, The Evolution of. By Lieutenant Nathan Sargent, U. S. N. Vol. IX., No. 5, p. 693.
Marine International Law. Compiled from Various Sources. By Commander Henry Glass, U. S. N. Vol. XI., No. 3, pp. 355–625.
Mignonette, The Case of. By Henry Winthrop Hardon, A. M., LL. B. Vol. XII., No. 2, p. 69.

MECHANICAL AND STEAM ENGINEERING.

Anchors, Apparatus for Letting Go. Professional Note. Vol. XII., No. 2, p. 251.
Annunciator, Baird's. Professional Note. Vol. XII., No. 3, p. 446.
Banked Fires. Professional Note. Vol. XII., No. 4, p. 648.
Baird's Steam Steering Gear, Notes on. Professional Note. Vol. XI., No. 4, p. 815.
Boiler Power of Naval Vessels. By Passed-Assistant Engineer Roelker, U. S. N. Vol. V., No. 3, p. 275.
Boiler, The Belleville Inexplosive. Professional Note. Vol. VIII., No. 4, p. 693.
Boiler, The Belleville. Translated by Professor J. Leroux, U. S. N. Vol. IX., No. 1, p. 103.
Boilers, The Care of, in the Navy. By Assistant Engineer W. M. Parks, U. S. N. Professional Note. Vol. X., No. 3, p. 517.
Broken Crank, Repairing with Wire Rope. Professional Note. By Passed-Assistant Engineer J. C. Kafer, U. S. N. Vol. VII., No. 1, p. 107.
Circulating Pumps for Surface Condensers, Different Types of. Professional Note. By Passed-Assistant Engineer Charles H. Manning, U. S. N. Vol. VII., No. 3, p. 335.
Coal, The Valuation of. By Professor C. E. Munroe. Vol. VI., No. 3, p. 221.
Compound Engines. By Chief Engineer C. H. Baker, U. S. N. Vol. I., No. 1, p. 59.
Same. Discussion of. Vol. I., No. 1, p. 71.
Condensers, Surface. By Cadet-Engineer J. M. Whitham, U. S. N. Vol. IX., No. 2, p. 303.
Cylinder Diameters of Marine Compound Engines. By Cadet-Engineer . M. Whitham, U. S. N. Vol. X., No. 3, p. 497.
Derrick, A New and Powerful. By Henry H. Gorringe, Esq. Vol. XI., No. 1, p. 158.
Excavating Machine, Mansfield's Hydraulic. By Lieutenant E. de F. Heald, U. S. N. Professional Note. Vol. X., No. 3, p. 520.
Fire Rooms, Closed. Professional Note. Vol. XII., No. 3, p. 447.
Forced Combustion. By Cadet-Engineer J. E. Byrne, U. S. N. Vol. XII., No. 4, p. 637.
Forced Draught by Revolving Screw in Chimney. By Passed-Assistant Engineer John C. Kafer, U. S. N. Professional Note. Vol. XI., No. 2, p. 334.

Indicator, The Steam-Engine, as a Detector of Lost Motion. By Robert Grimshaw, M. E. Professional Note. Vol. IX., No. 5, p. 803.

Kunstadter System of Rudder and Swivelling Screw, Report by a Board of U. S. Naval Engineers on the Relative Steering Efficiencies of the Rudder Alone, and the. Professional Note. Vol. XII., No. 2, p. 248.

Liquid Fuel, Notes on. Professional Note. Vol. XII., No. 2, p. 242.

Marine Engines, The Relations between Size, Speed, and Power of. Professional Note. Vol. IX., No. 2, p. 311.

Petroleum as a Source of Emergency Power for War Ships. By Passed-Assistant Engineer N. B. Clark, U. S. N. Professional Note. Vol. IX., No. 5, p. 798.

Propeller, The Fryer Buoyant. By Lieutenant W. A. Jaques, U. S. N. Vol. VIII., No. 3, p. 401.

Steam Cylinders, Condensation in. Professional Note. Vol. XII., No. 3, p. 444.

Steamship America. Professional Note. Vol. XII., No. 4, p. 645.

Steamships, The Comparison of. By Passed-Assistant Engineer T. W. Rae, U. S. N. Vol. II., No. 1, p. 77.

Same. Discussion of. Vol. II., No. 1, p. 90.

Steel Boilers, A Strange Failure of. Professional Note. Vol. XII., No. 2, p. 241.

Trenton, The U. S. S. By Passed-Assistant Engineer G. W. Baird, U. S. N. Vol. IV., No. 1, p. 5.

Trenton, The U. S. S. By Passed-Assistant Engineer G. W. Baird, U. S. N. Vol. V., No. 4, 443.

MERCHANT MARINE.

Merchant Marine, Our. The Causes of Its Decline and the Means to be Taken for Its Revival. Prize Essay, 1882. By Lieutenant J. D. J. Kelley, U. S. N. Vol. VIII., No. 1, p. 3.

Same. Honorable Mention. By Master C. G. Calkins, U. S. N. Vol. VIII., No. 1, p. 35.

Same. Honorable Mention. By Lieutenant-Commander F. E. Chadwick, U. S. N. Vol. VIII., No. 1, p. 75.

Same. Honorable Mention. By Lieutenant R. Wainwright, U. S. N. Vol. VIII., No. 1, p. 121.

Same. Printed by Request. By Ensign W. G. David, U. S. N. Vol. VIII., No. 1, p. 151.

Same. Discussion of. Vol. VIII., No. 3, p. 473.

METEOROLOGY.

Barometer in High Southern Latitudes. By Commander N. H. Farquhar, U. S. N. Vol. IV., No. 2, p. 113.

Revolving Storms; or, How the Wind Blows within the Storm Disk. By Lieutenant-Commander Thos. Nelson, U. S. N. Vol. V., No. 3, p. 231.

Wind, The Velocity of the. By Lieutenant J. F. Meigs, U. S. N. Vol. II., No. 1, p. 17.

NAVAL ARCHITECTURE AND CONSTRUCTION.

Anti-Corrosive Anti-Fouling Compositions for the Bottoms of Steel Ships, Tests of. By Lieutenant-Commander F. M. Barber, U. S. N. Professional Note. Vol. XI., No. 2, p. 331.

Bilge Keels, Notes on. By Assistant Naval Constructor F. T. Bowles, U. S. N. Vol. XI., No. 1, p. 119.

Centre of Gravity of the U. S. S. Shawmut, Experimental Determination of the. By Naval Constructor T. D. Wilson, U. S. N. Vol. I., No. 1, p. 149.

Corrosion of the Copper of the Juniata. By Professor Chas. E. Munroe. Vol. XII., No. 3, p. 391.

Corrosion of Steel, A Singular Case of. By Professor C. E. Munroe. Professional Note. Vol. VIII., No. 3, p. 502.

Corrosive Effect of Steel on Iron in Salt Water. Vol. VIII., No. 2, p. 327.

Cruiser for the U. S. Navy, A Proposed Type of. By Lieutenant J. C. Soley, U. S. N. Vol. IV., No. 2, p. 127.

Cruisers, Our New. By Assistant Naval Constructor F. T. Bowles, U. S. N. Vol. IX., No. 4, pp. 595–631.

Deep Sea Wave, The Theory of the. By Assistant Naval Constructor R. Gatewood, U. S. N. Vol. IX., No. 2, p. 223.

Iron and Steel, The Use of, in the Construction of Vessels of War. Discussion. Vol. VIII., No. 2, p. 267.

Ram, The Marine (as designed by Rear-Admiral Daniel Ammen, U. S. N.). By W. G. Gibbons, Esq. Vol. VIII., No. 2, p. 209.

Resistance of Full-Sized Ships, Towing Experiments on Models to Determine the. By Assistant Naval Constructor F. T. Bowles, U. S. N. Vol. IX., No. 1, p. 81.

Stability, Curves of. By Commander C. M. Chester, U. S. N. Vol. IX., No. 2, p. 257.

Stability, Curves of, of the Daphne and Hammonia. By Chas. H. Camp, Esq. Vol. XI., No. 1, p. 117.

U-Bow Section and a Long Buttock Line, A. By Lieutenant Seaton Schroeder, U. S. N. Vol. VIII., No. 3, p. 387.

Wave Motions. Professional Note. Vol. XI., No. 2, p. 340.

Wave Motion and the Resistance of Ships. By Professor J. M. Rice, U. S. N. Vol. VII., No. 4, p. 447.

Wood, The Preservation of. By Professor Chas. E. Munroe. Vol. III., No. 1, p. 73.

NAVAL POLICY.

I. Armored Vessel; II. Cruiser Best Suited to the Needs of the U. S., The Types of. Prize Essay, 1881. By Lieutenant E. W. Very, U. S. N. Vol. VII., No. 1, p. 43.

Same. Honorably Mentioned. By Lieutenant Seaton Schroeder, U. S. N. Vol. VII., No. 1, p. 85.

Same. Discussion. Vol. VII., No. 4, p. 453.

Intelligence, Naval. By Ensign Charles C. Rogers, U. S. N. Vol. IX., No. 5, p. 659.

Manning Our Future Naval Vessels, Some Suggestions for. By Commander Henry Glass, U. S. N. Vol. XII., No. 2, p. 41.

Naval Affairs. By Lieutenant Fred. Collins, U. S. N. Vol. V., No. 3, p. 159.

Naval Asylum and Service Pensions for Enlisted Men. By Lieutenant-Commander Chas. H. Stockton, U. S. N. Vol. XII., No. 2, p. 53.

Naval Policy, A View of Our, and a Discussion of Its Factors. By Commander Wm. Bainbridge Hoff, U. S. N. Vol. XII., No. 2, p. 121.

Naval Policy of the U. S. Prize Essay, 1880. By Lieutenant Chas. Belknap, U. S. N. Vol. VI., No. 4, p. 375.

Same. Discussion of. Vol. VII., No. 2, p. 155.

Naval Warfare as a Science, On the Study of. By Rear-Admiral S. B. Luce, U. S. N. Vol. XII., No. 4, p. 527.

Navy and Mercantile Marine, The Manning of Our. By Captain S. B. Luce, U. S. N. Vol. I., No. 1, p. 17.

Organization and Drill, What Changes in, are Necessary to Sail and Fight Effectively Our War Ships of the Latest Type? Prize Essay, 1886. By Lieutenant Carlos G. Calkins, U. S. N. Vol. XII., No. 3, p. 269.

Same. Discussion of. Vol. XII., No. 3, p. 317.

Same. Honorably Mentioned. By Ensign W. L. Rodgers, U. S. N. Vol. XII., No. 3, p. 361.

Purposes of a Navy, and the Best Methods of Rendering It Effective. By Rear-Admiral Daniel Ammen, U. S. N. Vol. V., No. 2, p. 119.

Reconstruction and Increase of the Navy, The. Prize Essay, 1884. By Ensign W. I. Chambers. Vol. XI., No. 1, p. 3.

Same. Discussion of. Vol. XI., No. 1, p. 61.

Rehabilitation, The Navy and Its Prospects of. Annual Address. By Rear-Admiral Edward Simpson, U. S. N., President of the Institute. Vol. XII., No. 1, p. 1.

Reorganization, Naval. By Captain A. P. Cooke, U. S. N. Vol. XII., No. 4, p. 491.

Rooms for Recreation and Places of Refuge for the Crews of the Several Squadrons. Translated from French Report by Lieutenant Duncan Kennedy, U. S. N. Vol. V., No. 2, p. 135.

Trained Seamen in the Navy, Inducements for Retaining, and the Best System of Rewards for Long and Faithful Service. Prize Essay, 1885. By Commander N. H. Farquhar, U. S. N. Vol. XI., No. 2, p. 175.

Two Lessons from the Future. By Lieutenant T. B. M. Mason, U. S. N. Vol. II., No. 1, p. 57.

Same. Discussion of. Vol. II., No. 1, p. 75.

Vessels of which the U. S. Navy Should Consist in Time of Peace, A Practical Method of Arriving at the Number, Size, Type, Rig, and Cost of. By Lieutenant-Commander F. M. Barber, U. S. N. Vol. XII., No. 3, p. 417.

NAVIGATION.

Astronomical Day, The Proposed Abolition of, and Its Bearing on Problems of Navigation. By Professor Stimson J. Brown, U. S. N. Vol. XI., No. 4, p. 753.

Astronomy, Uses of. By Rear-Admiral John Rodgers, U. S. N. Vol. V., No. 4, p. 449.

Azimuth Tables, To Determine by the Aid of, the Effect upon the Longitude of a Change in the Latitude Used in Working a Time Sight. Professional Note. Vol. VI., No. 4, p. 392.

Charts and Chart-Making. By Lieutenant J. E. Pillsbury, U. S. N. Vol. X., No. 2, p. 187.

Chart-Board, Deck. By Lieutenant A. Ross, U. S. N. Vol. IX., No. 5, p. 759.

China Seas, The Navigation of the. By Lieutenant Zera L. Tanner, U. S. N. Vol. V., No. 4, p. 181.

Chronodeik, The. Professional Note. Vol. VI., No. 3, p. 306.

Chronometers, Competitive Trial of, at the United States Naval Observatory. By Lieutenant E. K. Moore, U. S. N. Vol. XI., No. 1, p. 137.

Chronometers, Methods of Testing, at the U. S. Naval Observatory. By Lieutenant E. K. Moore, U. S. N. Vol. X., No. 2, p. 171.

Chronometers, Rules for the Care and Handling of. By T. S. and J. D. Negus. Vol. VIII., No. 2, p. 199.

Collisions at Sea. Professional Note. Vol. IX., No. 1, p. 131.

Collisions, the Avoidance of, at Sea at Night, and the Employment of Double Side-Lights. By Commander W. B. Hoff, U. S. N. Vol. XI, No. 2, p. 225.

Color-Blindness and Its Dangers on the Seas, The Synopsis of a Lecture on. By B. Joy Jeffries, M. D. Vol. VI., No. 1, p. 37.

Compass Correction in Iron Ships. By Staff-Commander E. W. Creak, R. N. Professional Note. Vol. VIII., No. 4, p. 685.

Composite Great-Circle Sailing, A Fallacy in. By Commander C. D. Sigsbee, U. S. N. Professional Note. Vol. XI., No. 2, p. 332.

Currents, Determination of, by a Series of Four Altitudes. Professional Note. Vol. XII., No. 3, p. 449.

Dangers of the Sea, Devices for Lessening the. By Captain R. B. Forbes. Professional Note. Vol. VI., No. 4, p. 395.

Deep-Sea Sounding. By Lieutenant-Commander T. F. Jewell, U. S. N. Vol. IV., No. 1, p. 37.

Duchemin Compass. Professional Note. Vol. V., No. 3, p. 294.

Forbes, R. B., A Letter from, to Professor W. A. Rodgers. Vol. VII., No. 4, p. 397.

Graphical Method for Navigators. By Commander C. D. Sigsbee, U. S. N. Vol. XI., No. 2, p. 241.

Gulf Stream, The. New Data from Investigations of the United States Coast Survey Steamer Blake. By Commander J. R. Bartlett, U. S. N. Vol. VIII., No. 2, p. 221.

Gulf Stream, The, Recent Investigations of. By Commander J. R. Bartlett, U. S. N. Vol. VII., No. 1, p. 25.

Ice Navigation. By Lieutenant Fred. Schwatka, U. S. A. Vol. VI., No. 4, p. 355.

Lunar Surface and Its Temperature. Professional Note. Vol. XII., No. 4, p. 647.

Nautical Almanac, The. By Professor Simon Newcomb, U. S. N. Vol. V., No. 2, p. 33.

Nautical Mile, On the Length of a. By J. E. Hilgard, Superintendent United States Coast Survey. Professional Note. Vol. VIII., No. 2, p. 317.

Navigation, A Brief Account of the Art of. By Lieutenant-Commander A. D. Brown, U. S. N. Vol. IV., No. 2, p. 95.

Navigation, A. D. 1594. By Lieutenant-Commander A. D. Brown, U. S. N. Vol. III., No. 1, p. 57.

Navigation, Aids in the Practical Work of. By Lieutenant A. Ross, U. S. N. Vol. VII., No. 4, p. 461.

Navigation, Aids to. By Lieutenant-Commander F. E. Chadwick, U. S. N. Vol. VII., No. 3, p. 255.

Navigation, The Coefficient of Safety in. By Professor W. A. Rogers, of Cambridge (U. S.) Observatory. Vol. VII., No. 3, p. 205.

Navigation, The Coefficient of Safety in. By Professor W. A. Rogers. (Concluded.) Vol. VII., No. 4, p. 353.

Navigation, The Coefficient of Safety in. By Commander P. F. Harrington, U. S. N. Vol. VII., No. 4, p. 385.

Navy Compass, Considerations Relative to Certain Fundamental Requirements of the Marine Compass, with Special Reference to the Construction of the. By Professor B. F. Greene, U. S. N. Vol. I., No. 1, p. 73.

Ocean Lanes. A Letter from Captain John Codman. Vol. VIII., No. 4, p. 675.

Ocean Lanes, Discussion on. Vol. VIII., No. 2, p. 285.

Oil, Use of. Professional Note. Vol. XI., No. 2, p. 339.

One Angle in Curved Channels, The Use of. By Commander H. C. Taylor, U. S. N. Vol. XII., No. 2, p. 105.

Parallel Rule, Sigsbee's Improved. By Commander C. D. Sigsbee, U. S. N. Professional Note. Vol. VIII., No. 2, p. 321.

Range Lights on Seagoing Ships. By Lieutenant F. F. Fletcher, U. S. N. Vol. XII., No. 4, p. 463.

Running Surveys, A New Method of Making. By Ensign John H. Fillmore, U. S. N. Vol. XI., No. 2, p. 269.

Sight Suitable to be Enforced in the Case of Signallers and Lookout Men and Other Persons, by Land or Sea, Tests of. Professional Note. Vol. VIII., No. 2, p. 323.

Speed Indicator, A New. Professional Note. By Ensign W. S. Hogg, U. S. N. Vol. VII., No. 3, p. 336.

Speed Indicator, Hogg's. Professional Note. Vol. VIII., No. 2, p. 322.

Spherical Triangles, An Instrument for Solving. By Rev. Thomas Hill, S. T. D. Vol. V., No. 5, p. 493.

Survey of the Coast, The. By Lieutenant G. L. Dyer, U. S. N. Vol. XII., No. 2, p. 199.

Tides, Their Cause. By Civil Engineer U. S. G. White, U. S. N. Vol. VIII., No. 3, p. 467.

Turning Circle, The, Application of Coast Survey Methods to the Determination of. By Lieutenant A. McCrackin, U. S. N. Vol. XI., No. 2, p. 265.

West Indies, Ports in the. By Lieutenant Chas. Belknap, U. S. N. Professional Note. Vol. XI., No. 4, p. 799.

ORDNANCE AND GUNNERY.

Boat Guns as Light Artillery for Landing Parties, The Employment of. By Lieutenant T. B. M. Mason, U. S. N. Vol. V., No. 3, p. 207.

Converted 8-inch M. L. Rifle. By Lieutenant Duncan Kennedy, U. S. N. Vol. III., No. 1, p. 47.

Corrections for Wind, Motion of Gun, and Speed of Target, and How to Allow for the Same. By Lieutenant R. R. Ingersoll, U. S. N. Vol. XI., No. 2, p. 207.

Gardner Gun, The. Professional Note. Vol. VIII., No. 2, p. 326.

Gunnery, Sladen's, Notes on. By Professor J. M. Rice, U. S. N. Vol. VIII., No. 1, p. 191.

Guns, Curves of Pressure in. By Lieutenant J. F. Meigs, U. S. N. Vol. XI., No. 4, p. 743.

Guns, High-Powered. A Study. By Lieutenant E. W. Very, U. S. N. Vol. VIII., No. 2, p. 233.

Longitudinal and Hoop Tension in a Thick Hollow Cylinder. By Lieutenant C. A. Stone, U. S. N. Vol. VIII., No. 3, p. 489.

Machine Guns. By Lieutenant W. A. Kimball, U. S. N. Vol. VII., No. 4, p. 405.

Machine Guns. The Gatling Gun: Its Positive Feed, High-Angle Fire, and Use in War. By Dr. R. J. Gatling. Vol. X., No. 2, p. 261.

One-Hundred-Ton Gun, The. By Lieutenant T. B. M. Mason, U. S. N. Vol. II., No. 1, p. 101.

Ordnance and Gunnery at the Naval Academy, The Present Course in. By Lieutenant R. R. Ingersoll, U. S. N. Vol. XII., No. 2, p. 91.

Ordnance Notes. By Lieutenant Chas. A. Stone, U. S. N. Vol. VIII., No. 4, p. 677.

Ordnance Notes. Professional Note. Vol. XI., No. 2, p. 335.

Ordnance Notes. Professional Note. Vol. XII., No. 4, p. 642.

Ranging Guns, A Proposed Method of, Applicable to Flat Trajectories. By Naval Cadet F. W. Jenkins, U. S. N. Vol. XII., No. 4, p. 477.

Rifled Ordnance, Our. By Lieutenant H. W. Lyons, U. S. N. Vol. VI., No. 1, p. 1.

Rifled Ordnance, The Development of. By Lieutenant E. W. Very, U. S. N. Vol. III., No. 1, p. 25.

Six-Inch B. L. R. By Ensign T. S. Rodgers, U. S. N. Vol. XII., No. 2, p. 77.

Small Arms, Magazine. By Lieutenant W. A. Kimball, U. S. N. Vol. VII., No. 3, p. 231.

Small Arms, The Lee System for. By James F. Lee. Vol. VII., No. 3, p. 325.

Steel for Heavy Guns. By Edward Bates Dorsey, Civil Engineer. Vol. XIII., No. 1, p. 1.

Same. Discussion of. Vol. XIII., No. 1, pp. 7–126.

Steel-Gun Factories, The Establishment of, in the United States. By Lieutenant W. H. Jaques, U. S. N. Vol. X., No. 4, pp. 531–909.

Velocity, Muzzle, On the Relation Existing between Length of Bore and. By Lieutenant C. A. Stone, U. S. N. Vol. IX., No. 1, p. 99.
Wire Guns, On the Tension of Winding. By Ensign Philip R. Alger, U. S. N. Professional Note. Vol. IX., No. 5, p. 793.
Wire Guns, On the Tension of Winding. By Ensign Philip R. Alger, U. S. N. Vol. XI., No. 1, p. 141.
Wire-Wound Guns. Professional Note. Vol. XI., No. 1, p. 149.

PERSONAL.

Morris, Charles, Commodore, U. S. N., Autobiography of. Vol. VI., No. 2, p. 115.
Parker, Foxhall A., Commodore, U. S. N. Obit. Vol. V., No. 5, p. 569.
Rodgers, John, Rear-Admiral, U. S. N. In Memoriam. Vol. VIII., No. 1, p. 197.
Rodgers, John, Rear-Admiral, U. S. N. Obit. By Professor J. Russell Soley, U. S. N. Vol. VIII., No. 2, p. 251.

TACTICS.

Battle Tactics: The Value of Concentration. By Commander H. C. Taylor, U. S. N. Vol. XII., No. 2, p. 141.
Same. Discussion of. Vol. XII., No. 2, p. 155.
Fleet Manœuvres in the Bay of Florida and the Navy of the Future, Our. By Commodore F. A. Parker, U. S. N. Vol. I., No. 1, p. 163.
Same. Discussion of. Vol. I., No. 1, p. 177.
Tactics, Naval. By Lieutenant-Commander Horace Elmer, U. S. N. Vol. X., No. 3, p. 487.
Torpedo-Boat Tactics. By Thos. Brassey, Esq., M. P. Professional N[illegible]. Vol. VI., No. 4, p. 400.

TORPEDOES.

Ericsson's Submarine Torpedo System. Professional Note. By Lieut. W. W. Kimball, U. S. N. Vol. VII., No. 3, p. 339.
Submarine Mines, Scandinavian Experiments with. Translated by Lieutenant W. H. Beehler, U. S. N. Vol. VII., No. 2, p. 121.
Torpedo Experiments at Portsmouth upon the Resistance. Professional Note. Vol. XII., No. 4, p. 641.
Torpedoes in Steam Launches against Men-of-War, The Employment of. Translated by Lieutenant T. B. M. Mason, U. S. N. Vol. VI., No. 1, p. 79.
Torpedoes, Their Disposition and Radius of Destructive Effect. By Lieutenant-Commander C. F. Goodrich, U. S. N. Vol. V., No. 5, p. 479.
Torpedo War and Submarine Explosions. By Robt. Fulton, 1810. Professional Note. Vol. XII., No. 2, p. 252.

MISCELLANEOUS.

Fortifications, Some Practical Hints about. By Captain J. C. Little. Vol. XII., No. 2, p. 175.
France, War Ships of, 1886. Professional Note. Vol. XII., No. 4, p. 644.

Intercepting and Chasing, etc., Notes on. By Lieutenant H. O. Rittenhouse, U. S. N. Vol. XI., No. 4, p. 723.

Life-Saving at Sea. By Lieutenant T. B. M. Mason, U. S. N. Vol. IV., No. 1, p. 77.

Mœris: The Great Reservoir of Middle Egypt. With Topography and Construction of the Pyramids. By Cope Whitehouse, M. A. Vol. XI., No. 2, p. 325.

Physalia, or Portuguese Man-of-War, The. By Midshipman W. E. Safford, U. S. N. Vol. VIII., No. 3, p. 413.

Refractometer, Interference Phenomena in a New Form of. By A. A. Michelson (Late Master, U. S. N.). Professional Note. Vol. VIII., No. 3, p. 495.

Trinity's Crew, The Rescue of the, from Heard's Island. By Ensign W. I. Chambers, U. S. N. Vol. IX., No. 1, p. 121.

Vessels of War, Rigging and Equipment of. Discussion. Vol. VIII., No. 3, p. 483.

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1. Competition for the Prize is open to all members, Regular, Life, Honorary, and Associate, and to all persons entitled to become members, provided such membership be completed before the submission of the Essay. Members whose dues are two years in arrears are not eligible to compete for the Prize until their dues are paid.

2. Each competitor to send his essay in a sealed envelope to the Secretary and Treasurer on or before January 1, 1888. The name of the writer shall not be given in this envelope, but instead thereof a motto. Accompanying the essay a separate sealed envelope will be sent to the Secretary and Treasurer, with the motto on the outside and writer's name and motto inside. This envelope is not to be opened until after the decision of the Judges.

3. The Judges to be three gentlemen of eminent professional attainments (to be selected by the Board of Control), who will be requested to designate the essay, if any, worthy of the Prize, and, also, those deserving honorable mention, in the order of their merit.

4. The successful essay to be published in the Proceedings of the Institute; and the essays of other competitors, receiving honorable mention, to be published also, at the discretion of the Board of Control; and no change shall be made in the text of any competitive essay, published in the Proceedings of the Institute, after it leaves the hands of the Judges.

5. Any essay not having received honorable mention, to be published only with the consent of the author.

6. The subject for the Prize Essay is, *Torpedoes.*

I. *Their place in naval warfare.*

II. *Character of the torpedoes and torpedo vessels required for the naval service of the United States.*

III. *Organization of our naval torpedo service and instruction of its personnel.*

IV. *Tactics to be employed in offensive and in defensive warfare.*

7. The successful competitor will be made a Life Member of the Institute.

8. In the event of the Prize being awarded to the winner of a previous year, a gold clasp, suitably engraved, will be given in lieu of a gold medal.

By direction of Board of Control.

CHARLES R. MILES,
Secretary and Treasurer.

ANNAPOLIS, MD., *April* 28, 1887.

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PROCEEDINGS

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The U. S. Naval Institute was established in 1873, having for its object the advancement of professional and scientific knowledge in the Navy. It now enters upon its fifteenth year of existence, trusting as heretofore for its support to the officers and friends of the Navy. The members of the Board of Control cordially invite the co-operation and aid of their brother officers and of others interested in the Navy, in furtherance of the aims of the Institute, by the contribution of papers and communications upon subjects of interest to the naval profession, as well as by personal support and influence.

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ARTICLE VII.

SEC. 1. The Institute shall consist of regular, life, honorary, and associate members.

SEC. 2. Officers of the Navy, Marine Corps, and all civil officers attached to the Naval Service, shall be entitled to become regular or life members, without ballot, on payment of dues or fee to the Secretary and Treasurer, or to the Corresponding Secretary of a Branch. Members who resign from the Navy subsequent to joining the Institute will be regarded as belonging to the class described in this Section.

SEC. 3. The Prize Essayist of each year shall be a life member without payment of fee.

SEC. 4. Honorary members shall be selected from distinguished Naval and Military Officers, and from eminent men of learning in civil life. The Secretary of the Navy shall be, *ex officio*, an honorary member. Their number shall not exceed thirty (30). Nominations for honorary members must be favorably reported by the Board of Control, and a vote equal to one-half the number of regular and life members, given by proxy or presence, shall be cast, a majority electing.

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